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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Illustrated Advertisement Page 81.

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See page 17, Jan. 26. 1134

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See Advertisement page 66, Jan. 26. 2402

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See's Patent Hydro-Pneumatic Ash Ejector. Great saving of labour. No noise. No dust. No dirt. Ashes discharged 30 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, Ltd., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4235

Centrifugals.

Pott, Cassels & Williamson, MOTHERWELL, SCOTLAND. 929

See half-page Advertisement, page 26, Jan. 19.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. H. STROMEYER, M.I.C.E. Founded 1854 by SIR WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 598

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For the benefit of INDIGENT BACHELORS and WIDOWERS of Good Character, over 55 years of age, who have done "something" in the way of Promoting or Helping some branch of Science.

Donations or Pensions may be granted to persons who comply with those conditions.

For particulars apply to Messrs. J. & J. TURNBULL, W.S., 58, Frederick Street, Edinburgh. X 499

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Papers, which will cover two days' Examination, will be set in the following four subjects:—

English,
Mathematics,
Mechanics,
General Physics.

The Examination for the 1923 Scholarships will be held in March at a date to be fixed later, and all Application Forms must reach the Committee not later than 15th February, 1923.

Full particulars and official Application Forms may be obtained from:—

THE SECRETARY, X 362
Scholarships Committee,
Messrs. NORTON & GREGORY, Ltd.,
1 & 3, Castle Lane,
Westminster, London, S.W.1.

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 575

American University Degrees

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Powering of Vessels.—A

Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1049, Offices of ENGINEERING.

TENDERS.

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of:—

Structural Steelwork for Carriage Repair Shop and Wheel Shop, Trichinopoly Workshops Scheme.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked: "Tenders for Structural Steelwork," must be left with the undersigned not later than Twelve Noon on Friday, the 2nd March, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of the Specification.

Copies of the Drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
31st January, 1923. X 537

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of

the following STORES, namely:—

	Fee for Specification.
No. 1.—SCREW JACKS	5s.
No. 2.—STEEL WORK for Bridges ...	10s.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Screw Jacks," or, as the case may be, not later than Eleven a.m., on Tuesday, the 13th February, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2,
London, 31st January, 1923. X 525

ADMINISTRATIVE COUNTY OF LONDON.

SOUTH WESTERN STORM RELIEF SEWER.

CONTRACT No. 2.

The London County Council invites

Tenders for the Construction

in Tunnel of an 11 ft. 4 in. internal diameter SEWER in Iron of a total length of about 1¾ miles together with outlet to the River Thames, Weir Chambers, Tumbling Bays, Side Entrances, etc., in the metropolitan boroughs of Lambeth, Wandsworth and Battersea.

The Specification, Form of Tender, etc., may be obtained on application to the Chief Engineer of the Council at the Old County Hall, Spring Gardens, S.W.1, upon payment of the sum of £10. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the Fee.

No Tender received at the County Hall, Westminster Bridge, S.E.1, after Four p.m., on Monday, 26th February, 1923, will be considered. The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, X 523
Clerk of the London County Council.

CITY OF LEICESTER.

ADDITIONAL PUMPING MACHINERY AT ABBEY PUMPING STATION AND BEAUMONT LEYS SEWAGE FARM.

THE SEWAGE WORKS AND FARMS COMMITTEE of the Leicester City Council invite

Preliminary Proposals, Designs and Quotations

for STEAM, ELECTRICAL or other type of PUMPING MACHINERY in connection with the Sewage Disposal of the City.

Particulars, together with General Conditions, outline Specification, Plans showing sites, etc., may be obtained at the City Surveyor's Office on payment of the sum of £5 (five pounds), which will be returned on receipt of a *bona fide* Proposal and Quotation.

Cheques, etc., to be made payable to the Leicester Corporation, and sent to the City Treasurer.

Proposals and Quotations on the Form supplied, addressed to "The Chairman of the Sewage Works and Farms Committee, Town Hall, Leicester," are to be delivered not later than Twelve noon, Monday, 12th March, 1923, and endorsed "PUMPING MACHINERY."

The Committee do not bind themselves to accept any Proposal or Quotation.

The acceptance of any Proposal and Quotation will be subject to the approval of the City Council and the Ministry of Health.

M. GEORGE MAWBEY, M.Inst.C.E.,
City Engineer and Surveyor.

Town Hall, Leicester.
January, 1923. X 457

STEPNEY BOROUGH COUNCIL.

ELECTRICITY SUPPLY.

RIVER WATER SCREENING APPARATUS.

The Electricity Supply Committee of the Stepney Borough Council invite

Tenders from Responsible

Contractors for the CARRYING OUT of the following, viz.:—

The MANUFACTURE, SUPPLY, and ERECTION complete of a RIVER WATER SCREENING APPARATUS to be fixed in a well on the Council's Wharf at their Limehouse Generating Station.

Copies of the General Conditions, Specification, Form of Tender and Drawings, may be obtained from Mr. Wm. C. P. TAPPER, M.I.E.E., Borough Electrical Engineer and Manager, No. 27, Osborn Street, Whitechapel, London, E.1, upon receipt of a deposit of Five Guineas. Deposits will be returned to *bona fide* tenderers after the Tenders have been considered by the Council. Additional copies, with drawings, may be obtained upon payment of the sum of One Guinea, which will not be returned. Copies of the specification and drawings may be inspected at the above-mentioned address by appointment.

Tenders on the form supplied, endorsed "Tender for Screening Apparatus," must be delivered, signed, sealed and addressed to the Chairman of the Electricity Supply Committee, at No. 27, Osborn Street, Whitechapel, London, E.1, not later than March 1st, 1923.

The Council do not bind themselves to accept the lowest or any Tender.

GEO. W. CLARKE,
Town Clerk.

Municipal Offices,
Raine Street,
Old Gravel Lane, E.1.
20th January, 1923. X 394

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply

of:—

1. SPIKES, Screw, Steel.
2. SPRINGS, Helical and Volute.
3. MATERIALS for Railway Carriages.

Forms of Tender may be obtained from the Director-General, India Store Department, Branch No. 18, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that office not later than Two o'clock p.m. on Friday, the 23rd February, 1923, for Nos. 1 and 2, and on Tuesday, the 6th March, 1923, for No. 3.

T. RYAN, X 493
Director-General.

CORK BLACKROCK AND PASSAGE RAILWAY.

The Directors are prepared to receive

Tenders for the Reconstruction

of ONE SPAN of the DOUGLAS VIADUCT.

Copies of drawings and specification may be had on application to the Company's Engineer, R. H. GOOD, M.Inst.C.E., at the address below.

Tenders must be delivered to the undersigned on or before Noon on 19th February, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. J. COPINGER,
Secretary.

Albert Street Terminus,
Cork. X 519

RICHMOND MAIN SEWERAGE BOARD.

STORM WATER TANKS.

The Board are prepared to receive

Tenders for the Construction

of TANKS, EFFLUENT and SEWAGE CHANNELS, SLUDGE DRAINS, and other works at the Main Drainage Works, in the Parish of Mortlake, Surrey.

Specification and drawings may be inspected at the Office of Mr. WILLIAM FAIRLEY, M.Inst.C.E., Parliament Mansions, Westminster, S.W., also at the Main Drainage Works, West Hall Road, Kew Gardens, where copies of the Bill of Quantities will be available after Saturday, 3rd February, and may be obtained on deposit of a crossed cheque for £3 3s. made payable to the Board, which deposit will be returned on receipt of a *bona fide* Tender.

Sealed Tenders, on forms provided, must be received by the undersigned on or before Twelve o'clock noon, Wednesday, 14th February, 1923.

Security for the due fulfilment of the Contract will be required in accordance with the provisions of the Public Health Act, 1875.

The Board do not bind themselves to accept the lowest or any Tender.

J. LESLIE G. POWELL,
Clerk to the Board.

The Sessions House,
Richmond, Surrey.
29th January, 1923. X 509

CITY OF NOTTINGHAM.

NORTH WILFORD POWER STATION, CONTRACT No. 3.

TO STRUCTURAL ENGINEERS.

The ELECTRICITY COMMITTEE is prepared to receive

Tenders, from Firms capable

of undertaking a contract for about:—

1350 tons of STEELWORK in Stanchions, Girders, Beams, Roof Trusses, etc.,
30 tons of GALVANISED WORK in corrugated sheeting, Chimney Aprons, Louvres, etc.,
30 tons of CAST IRON in Gutters, etc.,

required in connection with the construction of the above Station.

Drawings may be seen, and copies of General Conditions of Contract, Specification, Bill of Quantities and Form of Tender, etc., may be obtained on and after Monday, 5th February, 1923, on application to Mr. T. WALLIS GORDON, City Engineer and Surveyor, Guildhall, Nottingham, on payment of Two Pounds, which will not be returned.

Sealed Tenders, duly stating the time required for the completion of the work, are to be delivered in the official envelope provided, to the undersigned on or before Thursday, 22nd February, 1923.

The lowest or any Tender will not necessarily be accepted and the Committee reserve to themselves the right of dividing the work in any way they shall think fit, and Tenders will only be accepted from firms who conform to the conditions of the Contract, as regards paying the local standard rate of wages, etc., and to the working rules of the Nottingham District.

By order,
W. J. BOARD,
Town Clerk.

Guildhall, Nottingham.
29th January, 1923. X 503

APPOINTMENTS OPEN.

ARTILLERY COLLEGE, WOOLWICH.

DEPARTMENT OF MECHANICAL AND ELECTRICAL ENGINEERING.
(Professor J. J. GUEST, M.A., M.I.M.E.)

Applications are Invited for

the POST of SENIOR LECTURER in the Mechanical Engineering Section. Salary £500 to £600 per annum. Post is pensionable under the Federated Superannuation Scheme for Universities.

Applications should be made, in writing only, before 16th February, 1923, to THE ADJUTANT, Artillery College, Red Barracks, Woolwich, S.E.18, from whom further particulars can be obtained. X 481

Foundry Manager Required

for the control of two Foundries with total output of 3000 tons per annum. Must be capable man with knowledge of moulding machines and all quick methods. State full particulars.—Address, X 532, Offices of ENGINEERING.

Traveller, for Reinforced

concrete roads, West of England District. £500 and commission.—Address, X 505, Offices of ENGINEERING.

Capable and Energetic

ENGINEER REPRESENTATIVE WANTED, on commission basis, for Middlesbrough district, by crane builders. Must have good connection with steel works, etc.—Address, X 506, Offices of ENGINEERING.

London Representative Required

by firm of Stationary Semi-Diesel Crude Oil Engine Manufacturers. Applicants should have good technical experience and connection among Government Departments, Municipalities, District Councils and Power Users generally.—Address, X 516, Offices of ENGINEERING.

Required for Important Railway

in Argentine, ASSISTANT to Chief Mechanical Engineer; must have thorough Carriage and Wagon experience in all branches. Must not be more than 35 years of age. Commencing salary £1000 p.a.—Write, giving full particulars of experience and copies (not originals) of testimonials to BOX "A.C.M.E.," c/o DAVIES & Co., 95, Bishopsgate, E.C.2. X 492

Wanted, Draughtsmen Experienced

in Water Tube Boiler design; also for contract and lay-out work. Must be able to carry out duties without unnecessary supervision.—Address, stating age, experience and salary required, X 521, Offices of ENGINEERING.

Engineer to Take Entire

Charge of Drawing Office. Must be specialist in Aerial Ropeways. State full particulars, experience, salary, etc. — Address, X 446, Offices of ENGINEERING.

Wanted, Mechanical

ENGINEER for Ceylon, experienced in Gas and Oil Engines, structural steel work; single; experience in Tea and Rubber Machinery an advantage. Age not over 25 years.—Apply, giving full particulars, KEMISH, 30, Basinghall Street, London, E.C. X 487

Draughtsman Wanted with

experience in large steam and gas engine details. Progressive post.—Address, stating age, experience, salary required, and when at liberty, X 483, Offices of ENGINEERING.

Draughtsman Wanted, Experienced

in enclosed Refrigerating Machinery; first-class man only. Age, salary, full particulars.—Address, X 497, Offices of ENGINEERING.

Draughtsman Required for

general hoisting machinery. Age about 28. One used to Grab designing preferred. State experience and salary.—Address X 471, Offices of ENGINEERING.

Draughtsman Required, temporarily,

must be fully conversant with Paper Mill work.—Apply with full particulars to EDWARD LLOYD, LTD., Sittingbourne. X 5[illegible]

Draughtsman Wanted; Capable

Man with experience in design and testing of Marine Auxiliary Machinery, including steam and motor driven centrifugal pumps, fans, high speed engines, etc. State full particulars of experience, age, and salary required.—Address, X 490, Offices of ENGINEERING.

Engineer Draughtsman Required

QUIRED. Well up in plant construction and maintenance. Experience of Gas Producers, Boilers, Furnaces and Electrical equipment desirable. Good disciplinarian. Age 30 to 35.—Apply with particulars of experience and salary required, to HANS RENOLD LTD., Burnage Works, Didsbury, Manchester. X 50[illegible]

Draughtsman Required with

experience in design of Diesel or other High Compression Oil Engines. State age, experience, salary, and when at liberty.—Address, X 502, Offices of ENGINEERING.

Heating.—Wanted, Engineer-

DRAUGHTSMAN, experienced in Surveying, Levelling and preparing drawings for large heating installations on the Atmospheric System. Apply, giving age, experience and wage expected. Address, HEATING, WM. PORTEOUS & Co., Advertising Agents, Glasgow. X 5[illegible]

Draughtsman Required Immediately

by large firm of Engineers and Contractors for their London Office. Thoroughly experienced in designing and laying out Mechanical Handling Plants for large public works contracts. Only men with first-class experience as above need write.—State experience, age and salary required, to BOX 245, care of JUDD'S, 67, Gresham Street, E.C. 2. X 4[illegible]

Turbines.—Wanted, Assistant

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SUGGESTED SPECIFICATION FOR PERMANENT MAGNET STEELS.

By ELLIS H. CRAPPER, M.Eng., M.I.E.E.

THE pronounced demand for permanent magnet steels for magneto-magnets, other than those required for telephone sets, has brought into prominence the necessity for grading such steels into ordinary and special brands of permanent magnet steels. During the last ten years the electrical engineer has evolved designs resulting in the production of magnetos of very superior quality and reliability, and has been materially assisted by the metallurgical engineer, who has provided permanent magnet steels of the required quality. It appears to the writer that the time has arrived when it is not only possible, but essentially necessary, to grade such steels. The following suggested specification is consequently offered tentatively as one which makes reasonable demands upon the steel maker, and with the exception of one or two specific magnetic constants nothing is introduced that cannot be readily understood by those acquainted with the elementary principles of the magnetic circuit, and the graphical representation depicting the results of magnetic tests in the form of the complete hysteresis loop. Such a diagram gives the relationship existing between the resulting values of the flux-density B, as the magnitude of the magnetising force H is varied and reversed between the definite maximum values.

For the purposes of the design of ordinary dynamo-machines, in which magnetically soft iron is utilised, the relationship existing between the flux-density B and the magnetising force H is perfectly definite, and the application thereof is a simple matter. But in the case of the magnetically hard materials of which permanent magnets are made, the constant B is not so definite as a criterion of the nature and value of the steel for purposes of design. The constant I, technically known as the intensity of magnetisation, or the magnetic moment per unit volume, is given by the well-known relationship, $B = 4\pi I + H$, and it is suggested that the magnetic element which best specifies the inherent magnetic nature and quality of a permanent magnet steel is $I = \frac{B - H}{4\pi}$. For some purposes $4\pi I$ or $B_i = B - H$ (which is obviously the ferric inductivity of the material), is perhaps the magnitude which specifies the quality and condition of the material.

The values included in the following tables are suggested as a basis for comparison, and the values given for the coefficient of retentivity will obviously be found to differ slightly from the values generally quoted, in consequence of using B_i instead of B. The remanent flux-density, $B_{rem.} = 4\pi I_{rem.}$

Steels for permanent magnets are, for the purpose of this specification, divided into three grades, denominated :—

(1) Ordinary grade permanent magnet steel.
(2) Higher grade magneto-magnet steel.
(3) Special grades of permanent magnet steel.

1. The ordinary grade magnet steels include plain carbon and chrome steels as well as tungsten steel, suitable for the manufacture of permanent magnets which will not be subjected to vibration, shock or rough usage. These steels when properly treated thermally and tested ballistically in the form of a closed magnetic circuit, should possess magnetic characteristics or constants superior to the following minimum values, when the maximum value of the applied magnetising force $H_{max.}$ is not less than 400 C.G.S. units.

TABLE I.

Coercive force, $H_c = 58$ C.G.S. units.
Remanent flux-density, $B_r = 10{,}000$.
Coefficient of retentivity, $c = \frac{B_r}{B_{i\ max.}} = 0{\cdot}65$.
The product, $H_c \times c = 40$.
Magnetic strength, $H_c \times B_r = 560{,}000$.
Specific reluctivity at the remanence-point, $\frac{H_c}{I_r} = 0{\cdot}07$.
Available external magnetic energy $(\beta\phi)_{max.} = 240{,}000$.

2. The higher grade magneto-magnet steels include special chrome steels, tungsten steels and chrome-tungsten steels of such composition as will meet the requirements of magnetos intended for use with internal-combustion engines associated with motor, sea-craft and aircraft services.

The specific requirements for these services are a high degree of constancy of the magnetic characteristics, as well as higher values of the magnetic constants than those of grade (1).

The minimum acceptable values when tested under the specified conditions, are given in Table II.

TABLE II.

Coercive force, $H_c = 65$.
Remanent intensity, $I_r = 760$.
Coefficient of retentivity, $c = \frac{B_r}{B_{i\ max.}} = 0{\cdot}7$.
The product, $H_c \times c = 50$.
Magnetic strength, $H_c \times B_r = 600{,}000$.
Specific reluctivity at the remanence-point, $\frac{H_c}{I_r} = 0{\cdot}085$.
Available external magnetic energy $(\beta\phi)_{max.} = 300{,}000$.

3. The special-magnet steels include the more recently introduced cobalt steel and chrome-cobalt steel alloys, which are characterised by exceptionally high values of coercive force H_c, and satisfactory values of remanent flux-density and other magnetic constants. The tests for these steels must be made with magnetising forces of which the maximum value, $H_{max.}$, is not less than 1,500 C.G.S. units.

These steels should be easily worked, and not liable to crack unduly in the making and hardening processes.

The minimum acceptable values of the magnetic constants of these steels are given in Table III.

TABLE III.

Coercive force, $H_c = 200$ C.G.S. units.
Remanent intensity, $I_r = 800$.
Coefficient of retentivity, $c = \frac{B_r}{B_{i\ max.}} = 0{\cdot}625$.
The product, $H_c \times c = 125$.
Magnetic strength, $H_c \times B_r = 2{,}000{,}000$.
Specific reluctivity at remanence-point, $\frac{H_c}{I_r} = 0{\cdot}25$.
Available external magnetic energy $(\beta\phi)_{max.} = 600{,}000$ to $1{,}000{,}000$.

IMPULSE TURBINE *VERSUS* REACTION TURBINE FOR HIGH HEADS.

ALTHOUGH the impulse wheel is typically a high head unit using comparatively little water as compared with the reaction wheel which is a low head unit often using vast quantities of water, there are many factors which enter into a consideration of the choice between the two types of hydraulic prime mover, particularly for fairly high heads. In the following discussion the term "impulse wheel" is considered as restricted to the "Pelton" wheel, while as reaction turbines are now for the most part of the Francis type, especially when operating under high heads, the choice of impulse or reaction turbine virtually resolves itself into a choice between a Pelton and a high head Francis. The primary criterion for choosing between the two types is the specific speed formula.

$$N_s = \frac{\text{r.p.m.} \times \sqrt{\text{H P}}}{\text{H}^{\frac{5}{4}}}$$

Where H is expressed in feet, values of N_s below 9 call for an impulse wheel, values above 11 for a reaction turbine, while values between 9 and 11 fall within a debatable zone where other considerations usually determine the choice.

Theoretically, considering the specific speed formula alone, there is no limit to the head suitable for reaction turbines. Practically the revolutions per minute are limited by generator speeds, while horse-power is limited by quantity of water available. The higher heads can only be developed on mountain streams, which are usually of small volume. Even when a large volume of water is available at a high head, there are various mechanical difficulties in the design of a reaction turbine to fit the conditions. For instance, a casing large enough for the required volume of water must be of considerable thickness to withstand the heavy working pressure. This not only adds to the cost but a point is soon reached where it is difficult, if not impossible, to obtain sound steel castings of the requisite thickness and diameter. At the present time the highest head reaction turbines are those at the No. 3 plant of the Kern River development, Southern California. These were built by the Pelton Wheel Company and are of 25,000 h.p., and operate under an average head of 810 ft., and are of a particularly interesting design due to the peculiar operating conditions which call for different speeds for different electrical conditions at alternate seasons of the year, necessitating arrangements being made for changing the runners at short notice without disturbing the remainder of the apparatus. As a matter of fact, reaction turbines have been considered and even designed for heads of as much as 1,100 ft., but so far nothing of this kind has been built.

As regards impulse turbines the highest head with which it has as yet been attempted is 5,320 ft., and there are four 3,000-h.p. units of the Pelton type operating under this head at Fuliy, Switzerland, an installation which has recently been fully described in our columns.* This plant, like the Kern River plant, called for special arrangements in the shape of protective devices in case of pipe bursts or governor failures. Opportunities for development of such high heads are of course rare, at the present time few plants are working on heads higher than 2,000 ft., in fact it is often the better proposition to break up these high heads into two or more stages, as for instance, the Big Creek development in California with a total head of 6,000 ft., which will, when complete, be divided into five sections.

In the case of an impulse wheel, the head determines the spouting velocity from the formula $v = \sqrt{2gh}$. Given the water quantity and spouting velocity, the jet diameter is determined. This more or less fixes the wheel diameter, because, although special types of construction permit the use of a low ratio of runner diameter to jet diameter, an increase of the latter usually means an increase of the former. Therefore, if all the conditions of a project are kept constant except the horse-power output, the weight of an impulse wheel installation will increase more rapidly with increase in power output than will the weight of a similar reaction turbine. Consequently, when any given set of hydraulic conditions except the power output is kept constant, a point is reached, with increase of power output, where the cost of an impulse wheel installation exceeds the cost of a reaction wheel installation, although this would not seem to be readily apparent when the extreme simplicity of the impulse wheel is considered. Just where this point is in any given case cannot be determined in advance of a study of the conditions.

When, however, this point lies within the debatable zone, as determined by the specific speed formula, the question of cost may be so important as to be the determining factor. The specific speed for any given project may be varied considerably by varying the revolutions per minute or the capacity of the individual unit. The former course is occasionally adopted where a trial solution of the specific speed formula indicates a different type of unit than the one favoured by the other conditions, but it must be remembered that variation in revolutions per minute is limited by the range in generator speeds allowed by the electrical manufacturers.

For most large projects the maximum efficiency of a well-designed impulse wheel will lie between 84 per cent. and 88 per cent., while a similar reaction turbine would show better results by about 4 per cent. On the other hand, the impulse wheel will have a flatter efficiency curve. Consequently, when a plant must operate for a considerable part of the time on fractional loads, the average efficiency for an impulse wheel installation is likely to be higher than that of the corresponding reaction turbine, even if the maximum efficiency of the latter is higher. At the same time it must be borne in mind that the efficiency of the reaction turbine depends upon the maintenance of minimum clearnaces between the runner and other parts of the turbine. Corrosion and erosion may so reduce these clearances as to eventually call for renewal of runner and other costly parts. On the other hand these bad effects of the water are not so marked with

* See ENGINEERING, November 24, December 1, and December 15, 1922, pages 635, 665 and 731.

the impulse wheel, and in any case renewal of the worn parts is a simpler and cheaper matter. In fact, for this reason alone, a new development in Arizona operating on a comparatively low head of 110 ft. with a maximum quantity of water of 720 cub. ft. per second, incorporates impulse turbines of 1,000 h.p. each, although the conditions of head and quantity would appear to be the reverse of favourable. It so happens that the water is very corrosive, and being also used for irrigation is heavily charged with silt at certain periods of the year, while the requirements of the irrigation scheme render the water quantity very variable. Hence the choice of the impulse wheels which in this instance have vertical shafts and six nozzles, the number of which actually in service is varied according to the quantity of water available so that the efficiency curve is practically flat whatever the quantity of water.

It should be mentioned, of course, that water used for irrigation should not be robbed of its silt, in consequence settling basins are often inconvenient under such conditions, but the water supplied to the Kern River plant previously referred to is settled before passing through the turbines, and although most of the deposit is fine enough to pass a 200-mesh sieve, it would, if allowed to remain in the water, do considerable damage in view of the head and the fact that the turbines are of the reaction type.

In such cases the silt should be removed as far as possible in settling basins, but even then there is the risk of erosion if the water is initially charged with silt and the only means by which the designer can make provision for coping with it is to so arrange the turbine that easy access may be had to the interior without dismantling generator, shaft or bearings. The overhung construction is entirely suitable in this respect and in combination with renewable clearance rings permits of the operator observing and keeping track of the degree of wear of these rings without taking down the turbine. There are three such turbines, each of 11,300 h.p., operating under a head of 580 ft., at the Maitenes plant on the Rio Colorado, in Chile.

18-IN. REFRACTING TELESCOPE FOR THE BRAZILIAN GOVERNMENT.

Recently there has been erected at the Observatorio Nacional, Rio de Janeiro, an astronomical telescope, which, though of the generally well-known type of equatorial mounting, is of exceptionally good design, and embodies certain modern mechanical features specially suited to secure easy control by the observer. The instrument is also provided with a number of special accessories suited to the needs of the present-day astronomer. This is the third telescope constructed by the makers, Messrs. T. Cooke and Sons, Limited, of York, to the order of the Brazilian Government, and erected at Rio. The first one was described and illustrated in our issues of November 23 and 30, 1894. It had a 12½-in. object glass of 15 ft. 4 in. focal length. In 1909 the same firm supplied another equatorial with a 12-in. photo-visual object glass of 17 ft. 4 in. focal length and a following or guiding telescope of 8-in. aperture. A small illustration of this instrument is given in Fig. 1, annexed, and it may be of interest to compare its design with that of the larger telescope now installed, as shown in Fig. 2 on the opposite page.

The particular instrument we are about to describe viz., the 18-in. telescope,* is shown in Fig. 2 just referred to, and in Figs. 3, 4 and 5, on Plate X. From these views it will be seen that the instrument consists of a main telescope with two photographic star cameras placed side by side and above the main tube, while between the cameras and the large telescope is placed a smaller telescope for use as a guider either when long exposures are being made with the star cameras or when a camera which can be attached to the eye-end of the main telescope is in use. The main telescope has an achromatic object glass of 18 in. clear aperture and 21 ft. 4 in. focal length, and is provided with a double flap shutter and iris diaphragm working from full aperture down to a little over 2 in. Both are worked from the eye-end of the telescope, where there is a dial indicator which shows the amount of the diaphragm opening.

The two supplementary cameras have triple photographic lenses of the well-known Cooke type, 10-in. aperture and about 67 in. focal length. These cameras take plates 24 cm. by 30 cm. The guiding telescope has a 10-in. ordinary doublet object-glass of about 12 ft. 9 in. focal length. At its eye-end there is a sliding fitting by which the intersection of the cross lines in the eyepiece can be set on any selected guiding star in the field for the purpose of carefully following it while a long exposure is being made with the photographic cameras.

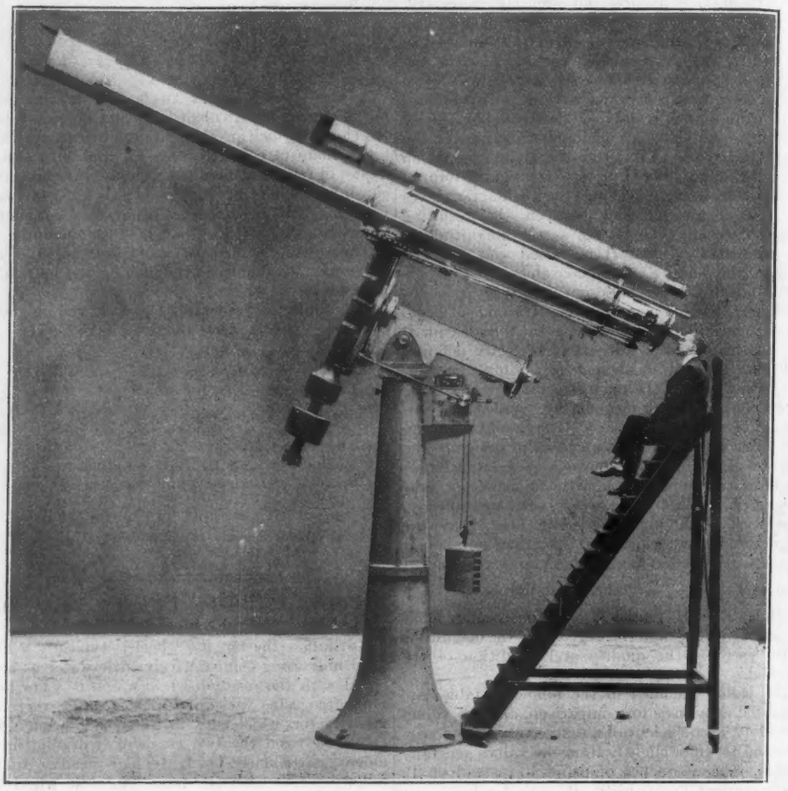


Fig. 1. 12-In. Photo-Visual Equatorial Telescope erected in 1909.

Fig. 2 on page 131 shows the general arrangement of the telescopes and mounting. The latter is of the usual type, with declination and polar axes carried on a substantial iron pillar within the head part of which is placed the clock. This, by means of suitable gears, gives the required motion to the polar axis, and causes the telescope to follow a star or planetary body in its apparent course. Fig. 3, on Plate X, is a view of the upper part of the instrument as seen through the shutter opening in the revolving dome over the circular building in which the instrument is housed. Figs. 4 and 5, in the same Plate, show the lower part of the mounting with the telescope group in different positions.

We will now proceed to describe in some detail the construction of the instrument. Figs. 6 and 7, on Plate XI, are side and end views of the main tube, guider and cameras. The main telescope tube is in three parts, the two conical ends being built up of planished steel sheets of two thicknesses and riveted together, with the thicker sheets near the middle of the length of the tube. The centre piece is of cast-iron bolted direct on the end of the declination axis as shown in Figs. 6 and 11, on Plate XI. This axis is of forged steel and turns in plain gun-metal bushes pressed into the ends of a socket casting, while to reduce collar friction when the axis moves from the horizontal position, a double thrust ball bearing is added.

The polar axis is also a solid steel forging. It is shown full length in Fig. 13, Plate XII, with the upper end in more detail in Fig. 8, on Plate XI. Further details of the lower end of this axis will be dealt with later on. Both ends of this axis revolve in ball bearings, the lower end having a ball thrust bearing also. The fitting of ball bearings to the polar axes of equatorial mountings, was a matter of some consideration to Messrs. Cooke, who, as pointed out in a letter we published in Engineering, vol. cxii, page 249, were the first to use them for this purpose. Their introduction has been attended with complete success, for, in addition to rendering a large telescope easy to set, the work required to be done by the driving clock is much reduced. The strain and wear on the driving gear being also reduced the high degree of accuracy which those parts possess is more likely to endure.

The extent to which such accuracy is endeavoured to be carried out in the gear can be shown by describing the care that is taken in the manufacture of a main driving wheel for such a telescope. The one under notice and shown in Figs. 8 and 11, is a little over 4 ft. 9 in. pitch diameter, and has 720 teeth in its rim. As disengaging the driving worm from the wheel is to be avoided as much as possible if permanent accuracy of the finely-cut teeth is to be secured, it is necessary, for the purpose of quickly rotating the polar axis when setting the telescope, that the wheel shall remain stationary and in gear with the worm while the axis or centre piece on which the wheel is mounted is being rotated within it. Now the slackness ordinarily allowed between one mechanical element which turns inside another is not permissible in a wheel of this kind, the fit having to be such that were it and its centre piece made of metals with greatly different coefficients of expansion such as cast-iron and gun-metal, and these, say, a few feet in diameter, the permissible slackness would be so small that, under

* Since this telescope was constructed Messrs. T. Cooke and Sons, Limited, have amalgamated with Messrs. Troughton and Simms, and the title of the joint firm is now Messrs. Cooke, Troughton and Simms, Limited, of London and York.

one extreme of temperature to which telescopes are subject, the parts would bind together, while at the other extreme the slackness would be so great that the accuracy of the instrument would be impaired. For this reason, and to avoid risk of deformation due to the same cause in an unmachined wheel with arms, Messrs. Cooke prefer to make the driving wheels of their equatorials as simple discs which are turned all over, and if of large diameter, are left to season for a considerable time before the teeth are cut in the edge.

For the cutting of the teeth mechanical appliances and processes of a high order are necessary to secure success. One feature of the modern astronomer's ideal equatorial is that it

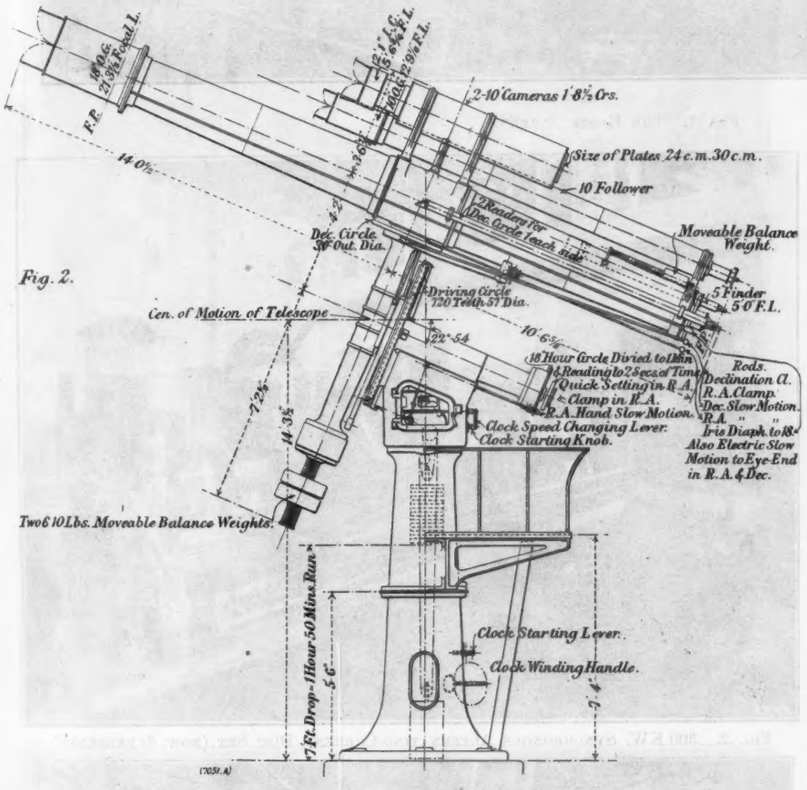

18 Ins. 29½ Focal L.
F.E.
14 0½
2-10 Cameras 1'8½ Ors.
Size of Plates 24 c.m. 30 c.m.
10 Follower
Reading for Dec. Circle (each side)
Moveable Balance Weight
Dec. Circle 56 Out. Dia.
Driving Circle 120 Teeth, 57 Dia.
5 Finder 5'0 F.L.
Cen. of Motion of Telescope
22·54
10' 6¾
18 Hour Circle Divided to Min. & Reading to 2 Secs. of Time
Quick Setting in R.A.
Clamp in R.A.
R.A. Hand Slow Motion
Clock Speed Changing Lever
Clock Starting Knob
Rods. Declination Cl. R.A. Clamp. Dec. Slow Motion. R.A. " Iris Diaph. to 18" Also Electric Slow Motion to Eye-End in R.A. & Dec.
Two 6 10 Lbs. Moveable Balance Weights
7 Ft. Drop - 1 Hour 50 Mins. Run
Clock Starting Lever
Clock Winding Handle
7035.A

Fig. 2.

FIG. 2. 18-IN. EQUATORIAL TELESCOPE WITH TWO PHOTOGRAPHIC STAR CAMERAS, ERECTED IN 1922.

should run with such regularity that a star placed between the close double cross-wires of an eyepiece or micrometer will continue in exactly the same position during the whole of the 3 hours or 4 hours a photograph of a star field is being taken. Failing this, incessant and keen observation must be kept and corrections made in the speed rate of the instrument while a photographic plate is being exposed, so as to avoid the star spots on the plate dragging into lines and rendering accurate measurements either of the relative star positions or brightness impossible.

It will thus be evident what kind of accuracy the driving wheels of large astronomical telescopes must possess. Usually the process first involves the cutting of very fine and short lines on a strip of silver let into the edge of the wheel, the lines corresponding with the number and position of the teeth to be cut. The lines on the driving wheel of the telescope now under notice were cut on a large automatic dividing engine (the making of such machines being one of Messrs. Cooke's specialities) of extremely high accuracy. We may, at some future date, give a description of one of these machines and the processes adopted in its manufacture, but for the present we may say that the cutting of the final divisions on the periphery of its main wheel or table and from which its 720 teeth were afterwards cut, involved over 50,000 micrometer settings. The work of making this disc wheel alone covered the greater part of two years' constant work. The resulting pitch error, measured singly or cumulatively, in the divisions so corrected amounted to no more than half a second of arc, or a lineal error of only $\frac{1}{20,000}$th of an inch.

After the cutting of the lines above mentioned, each division of the wheel in turn is set between the lines in the field of a microscope mounted on a special gear-cutting machine, and correspondingly accurate teeth cut in turn. The teeth are not afterwards touched by a tool. Hobbing is not permissible. Even the small amount of distortion usual in case-hardened hobs is fatal to the accuracy of such a wheel, and ground hobs of small pitch are not easily made. The most that is done is to run the wheel for a week or two in gear with its own driving worm (of fine unhardened steel) and to use fine rouge to induce a smooth running tooth surface where contact takes place.

On such a machine are the teeth divisions of a large telescope driving wheel first inscribed, and such is the quality of the mechanical work endeavoured to be put into the wheel. Even so, its accuracy must still fall far short of the optical perfection of high-class lens work.

The driving wheel for the Rio 18-in. telescope is fitted with a gun-metal rim shrunk on a central disc and securely fixed by a number of screws. This is shown in Fig. 8. Its large diameter has the effect of throwing the telescope axis further from the polar axis and increasing the weight of the parts to be moved, but the little extra work and friction thereby caused are of small account compared with the advantages of a large and accurately-cut wheel. Fig. 8, on Plate XI, shows clearly a fixed ring of channel section around the driving wheel rim which protects the teeth of the latter. The worm is also cased in.

The large scale view of the declination and polar axes (Fig. 8, Plate XI) also shows clearly the gears and rods for actuating the right ascension clamp from the eye-end of the main telescope and also from the lower end of the polar axis when the setting of the telescope for star positions is effected. It will be noticed that the right ascension clamp rod to the hour circle is taken through a central hole in the polar axis, and it is worked by a small hand-wheel on the rod end close to the circle. By means of a slightly larger hand-wheel near, and fixed to, the end of the polar axis, the whole of the moving parts, telescope counterweights and axes, can be turned with ease so freely does the polar axis revolve in its ball bearings and so well balanced in every direction are the rotating parts. The two hand-wheels just referred to will be seen in position in Fig. 13 on Plate XII.

It is evident that with such freedom of the instrument provision must be made for perfect balance on the two axes of the mounting. Not only must the opposite ends of the telescope group balance around the declination axis but the combined telescopes must be well balanced around the polar axis by means of the adjustable counterpoises mounted for that purpose on the other end of the declination axis. If this point is not attended to the work required from the driving clock will be irregular and uniformity of speed will be endangered.

To effect the necessary adjustment of balance due to the use on the eye-end of the telescope of accessories of widely differing weights it has been a common practice to fit a sliding weight on the side of the telescope. Such a weight, though very small, is seen on Fig. 3, Plate X, but in this case it is provided for final delicate adjustment only, as all the accessories for the eye-end of the telescope (except the very small eyepieces of negligible weight) such as the position micrometer, spectroscopes, and camera are all of the same weight. Thus whichever is used the good balance of the telescope remains undisturbed. Each accessory has a large bayonet-joint flange and can be quickly taken on or off the telescope. This has been Messrs. Cooke's practice on their more important telescopes for many years and is much appreciated by the users.

Ball bearings are employed for most of the constantly-moving parts of the mounting to keep down the work required of the main driving clock. In addition to the polar axis bearings the tangent worm spindle is so fitted, as are also certain of the quickly-running or heavily laden spindles of the clock itself.

Figs. 15 to 20, on Plate XII, show details of the box casting mounted on the top of the main column. This casting supports the polar axis socket and also forms a casing in which the driving clock is placed. Glass doors hinged at the sides of the casing give convenient access to the clock. The whole forms a very neat arrangement.

(To be continued.)

THE MARCONI TRANSATLANTIC WIRELESS STATIONS AT CARNARVON AND TOWYN.

WIRELESS communication between Great Britain and the United States of America is conducted at the British end by Marconi wireless stations at North Wales. The transmitting station is in Carnarvon (where, at the present time, the largest valve panel in the world is in use), and the receiving station is at Towyn. The history of these two stations shows how rapid the advance of high-power wireless communication has been during the last ten years. As one improvement has succeeded another in wireless science it has been adopted at Carnarvon or Towyn in order to keep the Transatlantic service up to date. In this article we give a historical survey which is of great interest as showing the developments which have taken place in transmission and reception.

Carnarvon Station.—The Carnarvon station which has been a prominent landmark for the past nine years, is built on the western side of Cefn-du Hill, one of the lesser heights of Snowdonia, 5 miles east of the town of Carnarvon, and overlooking the Menai Straits and Anglesey. The site on which the buildings and masts are erected is a strip of land 5,600 ft. long by 850 ft. wide, running in a direction approximately east and west.

A plentiful supply of water for cooling and general

THE MARCONI TRANSATLANTIC WIRELESS STATION AT CARNARVON.

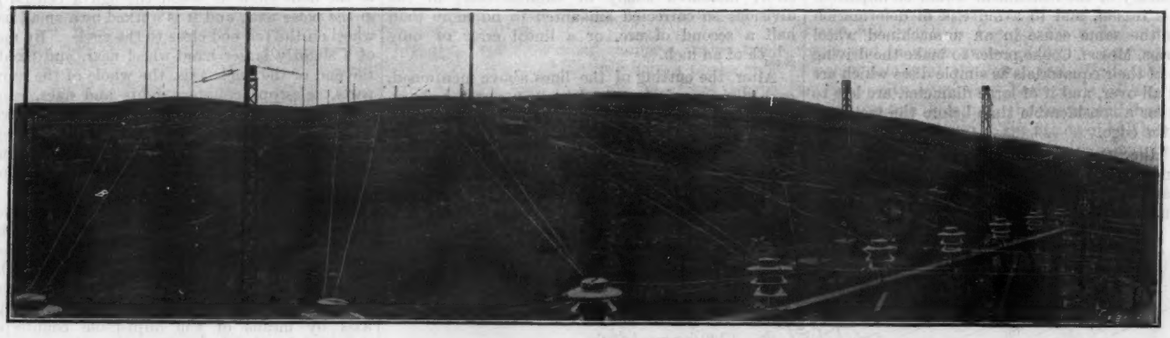


Fig. 1. The Earth Screen.

purposes is given by mountain-streams feeding a reservoir of 50,000 gallons capacity, built at a height of 120 ft. above the level of the station buildings. Owing to the heavy average rainfall in this district, the soil is always moist and provides a good "earth" for the wireless circuit, although, as will be seen later, the resistance of the ground underneath the aerial is now of minor importance as a factor in the choice of sites for modern wireless stations. The average gradient of that part of Cefn-du on which the station is built is approximately 1 in 7½, the western and eastern boundaries of the site being respectively at 620 ft. and 1,400 ft. above sea level. The principal buildings, including the machinery-house, substation and staff residence, are substantially built of brick with rough-cast exterior; the battery-house, store-sheds, rigger's huts, &c., are of wood and galvanised iron.

Power is supplied to the station from the North Wales Power Company's hydro-electric stations at Cwmdyli and Dolgarrog. Two lines carrying three-phase 50-cycle current at 10,000 volts connect the power stations to the wireless station, one being an exclusive line, the other, which is used as an emergency supply, being a branch from a line supplying other consumers. Each line is connected to the primary of a 500 k.v.a. transformer through lightning arresters and oil switches, the secondary and low-tension sides of the transformers delivering current at 440 volts to the two-feeder switches on the station main switchboard.

Carnarvon Aerial System.—The aerial, which is of the "inverted L" type and composed of 20 wires, each 3,900 ft. long, is supported by 10 tubular steel masts, each 400 ft. in height, the diameter of the lower half of the masts is 3 ft. 6 in., and that of the upper half 2 ft. 6 in. Each mast is bolted to a concrete foundation block and is guyed in four directions by five sets of insulated guys, each set of five guys having a common anchor block placed 200 ft. from the base of the mast.

The ten masts are arranged in four lines of three, two, two and three masts respectively, the lines being at right angles to the centre line of the aerial which lies in a direction 76 deg. West of North. The first row of three masts is placed 600 ft. from the transmitting building, the distance between the two outer masts on this line being 450 ft. The second line of masts is placed 900 ft. from the first and has a span of 500 ft. The third line is placed 900 ft. from the second with a span of 550 ft.; the fourth and last line being 900 ft. from the third with a span of 600 ft.

Between the mast-heads on each line steel triatics are slung, insulated at each end by a series of porcelain reel insulators, steel halyards are provided for raising and lowering the triatics with the aid of hand-operated winches. Spaced along the triatics on each line are 20 sets of five porcelain suspension insulators in series, to the lower end of which the aerial wires are attached. These 20 wires are of $\frac{7}{14}$ L.S.G. stranded silicon bronze, having a breaking strain of 1,350 lb., and are insulated at each end by two 3-ft. porcelain rod insulators in series, the whole

Fig. 2. 300-KW. Synchronous Alternating-Current Disc Set (now Superseded).

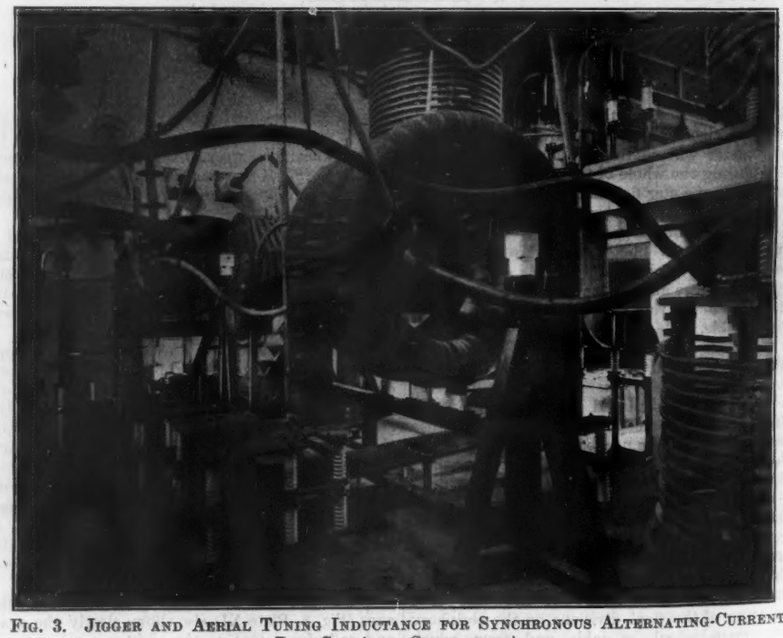


Fig. 3. Jigger and Aerial Tuning Inductance for Synchronous Alternating-Current Disc Set (now Superseded).

THE MARCONI TRANSATLANTIC WIRELESS STATION.

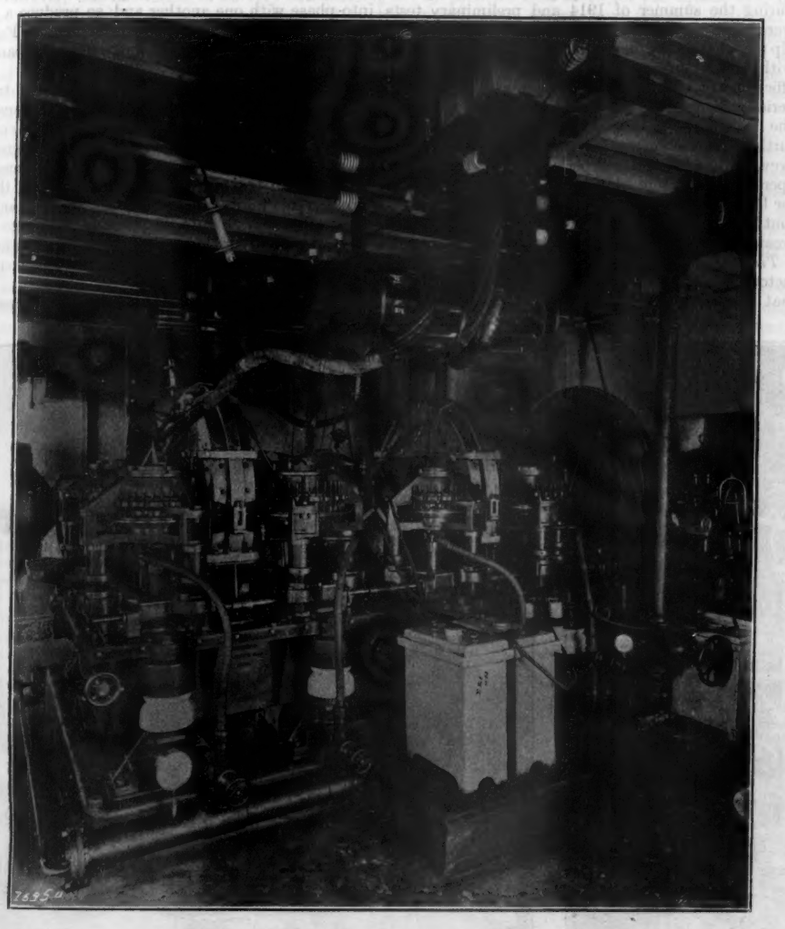


FIG. 4. CONTINUOUS-WAVE DISC DISCHARGER (NOW SUPERSEDED).

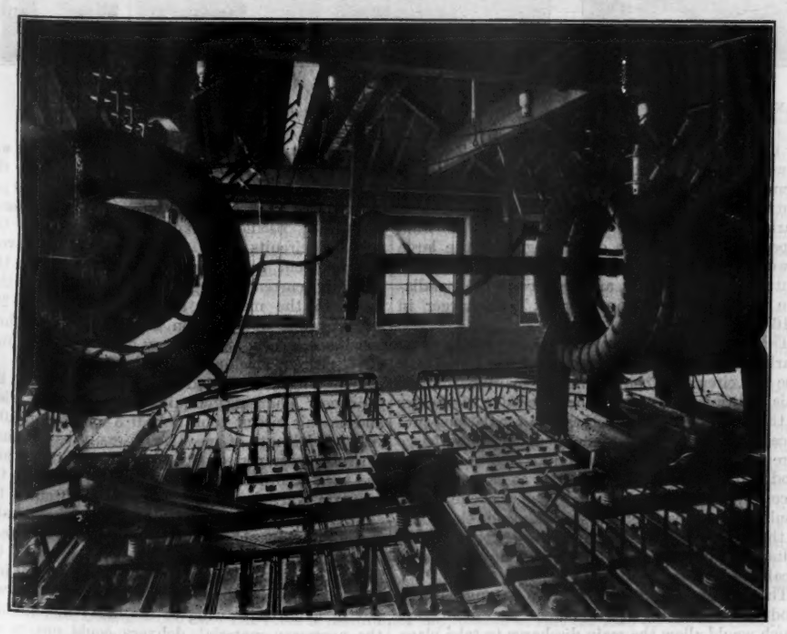


FIG. 5. JIGGER AND CONDENSER BANK FOR CONTINUOUS-WAVE DISC DISCHARGER (NOW SUPERSEDED).

aerial being capable of standing a potential difference to earth of 90,000 volts.

At the building, or western end of the aerial, the strain on the wires is taken by steel wires attached to the lower end of the rod insulators and passing over the building to a common anchor block; connecting leads from the insulated terminal, which passes through the wall of the building, are taken to the upper side of these rod insulators. At the eastern end of the aerial the wires are not taken to a common anchor block, as at the building end, but in order to keep the capacity as large as possible by maintaining the full width, they are strained to a line of 20 anchor blocks placed 800 ft. from the fourth line of masts. The aerial wires terminate 400 ft. from the fourth line of masts; the height of the rod insulators above the ground at this point is 250 ft. The capacity of the whole aerial to "earth" is 0·039 mfd., and its natural wave-length 5,400 m.

One of the most important points to be considered in the design of high-power wireless stations is the efficiency of the whole aerial circuit. The power absorbed by this circuit is C^2R, the product of the square of the current in the circuit and its total resistance; the total resistance R being the sum of the resistance due to radiation, the resistance of the conductors in the circuit, the eddy-current losses in conductors, and the di-electric losses in any capacities included in the circuit and in neighbouring insulators or partial conductors.

The only useful resistance in the circuit is that due to radiation, and as this is proportional to $\frac{h^2}{\lambda^2}$, the amount is small in the case of long-distance stations where long wave-lengths are necessarily employed.

It is therefore of great importance to reduce all other resistances and losses to the lowest practicable figure in order to obtain a reasonable efficiency.

In the original design of the station provision was made for the use of an earth connection consisting of a number of wires buried about 6 in. below the surface of the ground underneath the aerial. Around the building galvanised-iron plates, placed vertically about 3 ft. below the surface of the ground, are arranged in the form of a circle of 100-ft. radius, with its centre at the building. To this circle of plates, the earth wires from underneath the aerial are connected, and from here also leads are taken above the surface to a terminal forming the earth connection to the transmitter. It was found, however, that this form of return-path for the aerial current offered a considerable resistance, notwithstanding the fact that the soil was moist and was of the nature of what was generally considered at that time as a "good earth."

The Earth Screen.—Investigations were accordingly carried out and experiments conducted by the company's research engineers which resulted in the subsequent use of what is known as the "earth screen." This consists of an insulated network of wires supported a few feet above the ground, the wires forming the screen being joined together near the building, and connected to the transmitter in place of the "earth." The object of this network is to screen the ground from the electric field produced by the aerial; and to be thoroughly effective it should extend beyond the area occupied by the aerial by an amount at least equal to the height of the aerial above ground.

At this station the "earth screen" consists of 32 copper wires each 4,300 ft. long supported by insulators attached to triatics stretched between the tops of lattice steel masts 30 ft. in height. The screen is illustrated in Fig. 1, on page 132. At the building end the wires converge to a number of terminal insulators placed on a steel structure, and from which they are connected to two wall insulators, one on each side of the aerial terminal insulator. By this means the ground is effectively screened from the field produced by the aerial, and the improvement in efficiency which has resulted may be shown by figures of the aerial resistance, which with the earth connection was 1·4 ohms at 14,000 m., but which has been reduced by the use of the "earth screen" to 0·62 ohm at the same wave-length.

The saving in power required to produce 300 amperes in the aerial is thus considerable, C^2R being 126,000 in the case of the earth connection and

56,000 in the case of the screen connection, showing a saving of 70 kw. In addition to the improvement in efficiency due to the earth screen, further improvements have been made by investigating and reducing to the lowest limit the losses due to the high frequency resistance of the conductors, of which the inductances in the circuit are constructed and also by reducing the di-electric losses in condensers and partial conductors in proximity to high-potential portions of the circuit.

The final result of these improvements up to the present has been a reduction in the total aerial circuit resistance, including inductance coils from 2·1 ohms to 0·9 ohm, which represents a saving of 108 kw. in producing 300 amperes in the circuit. Further improvements are contemplated which are expected to bring the total resistance of the circuit down to 0·5 ohm.

The Earliest Transmitter.—A description of the various types of transmitters that have been installed at this station, shows very well the progress that has been made in the development of the transmitter for long-distance signalling during the last few years. The original equipment of the station consisted of two 300 kw. transmitters of the synchronous spark type. This type of transmitter consisted of a copper-studded steel disc rotating between two slowly-revolving copper electrodes connected to a condenser—inductance circuit. The steel disc was mechanically coupled to the extended shaft of a motor alternator and consequently rotated synchronously with it. The bank of condensers included in the circuit was charged by transformers connected to the alternator and discharged through the gap formed by the copper electrode and rotating studs, the energy in this circuit was transferred to the aerial through an electromagnetic coupling.

The number of studs on the disc corresponded with the number of poles of the alternator and adjustments of the alternator armature were provided whereby the condenser could be charged at the peak of the alternator cycles. The alternator ran at 1,500 r.p.m. and delivered current at 150 cycles per second, the spark frequency being therefore 300 per second. Signalling was effected by the operation of a switch in the charging circuit of the condenser; an air blast of 2 lb. per square inch, was provided to extinguish the arc which tended to form when the circuit was broken. One of these sets is illustrated in Fig. 2, on page 132, and the jigger in Fig. 3, on the same page.

The installation of this equipment was completed during the summer of 1914 and preliminary tests were being made with America when war broke out. Up to this time the maximum aerial current obtained with this transmitter was 220 amperes with an efficiency of about 30 per cent. from alternator to aerial. Shortly after this the station passed under the control of the Post Office for war purposes and further developments of the transmitter were prevented. From the experience gained from the operation of this machine it became evident that for long-distance signalling a transmitter producing continuous waves was essential in order to obtain greater selectivity.

Timed-Spark Discharger.—At this time no satisfactory continuous wave transmitter was available that would handle the amount of power required for the range over which this station was intended to work. Experiments on a small scale had already been carried out on a machine which produced continuous waves by the proper timing of a series of spark discharges; and as this type of machine appeared to be capable of dealing with the large power required for the station, its development was continued at Carnarvon, and resulted in the installation of a 200-kw. "timed-spark" discharger in 1916.

This machine was somewhat similar to the plain spark discharger, but with the addition of another disc and circuit for controlling the main discharges. This additional disc timed the successive discharges of the main condenser so that the oscillations produced in the aerial by one main condenser discharge bore the correct phase relation to the oscillations produced by a previous discharge, so as to produce a continuous train of oscillations. To effect this result, the gaps between the studs and side electrodes of the main disc were increased in length until the voltage across the condenser was insufficient to break them down.

The timing circuit was then so arranged as to produce an ionising spark across the main gaps which would allow the main discharge to take place, and adjustments were provided to control the instant at which this ionising took place. By this means a series of discharges at perfectly regular intervals was secured and by running the disc at a constant and definite speed, the oscillations produced by the successive discharges could be brought into phase with one another and so produce a continuous wave. The machine is shown in Fig. 4, on page 133, and the jigger and condenser bank in Fig. 5.

The oscillations produced by this type of transmitter, although continuous, were not of constant amplitude; as, owing to the damping of the aerial circuit, the oscillations produced therein decreased in amplitude in the interval between successive discharges of the primary circuit. In order, therefore, to maintain the amplitude as constant as practicable a high rate of primary discharge was necessary; and for this reason two separate primary circuits were employed in the final arrangement of the transmitter.

Shortly after this machine was put into service the wave-length at which the station operated was changed from 11,000 m. to 14,000 m., and for the latter wave-length a primary discharge of 1,580 per second was used giving an impulse to the aerial every 13½ oscillations. The condensers of the primary circuits were charged by a 5,000-volt direct-current generator of 300 kw. capacity, the charging current being 50 amperes. With this input to the machine an aerial current of 280 amperes was obtained on a circuit of 2·1 ohms resistance, giving an efficiency of 66 per cent. from direct-current machine to aerial.

Signalling was effected by means of a key in the condenser charging circuit of the timing disc; and as this circuit took only 0·3 ampere at 5,000 volts a high rate of speed could easily be obtained. On full power perfect signalling from this machine has been recorded at 195 w.p.m., but owing to the comparatively slow rate at which the current in the aerial rises, this speed of signalling is not practicable for working over the maximum range, as the signals do not reach their full strength in the dots of the Morse Code. As soon as this machine was put into service, the manufacture of a duplicate set was put in hand, but owing to the delay in obtaining the necessary material, delivery could not be expected for a considerable time.

Poulsen Arc Transmitter.—In the meantime,

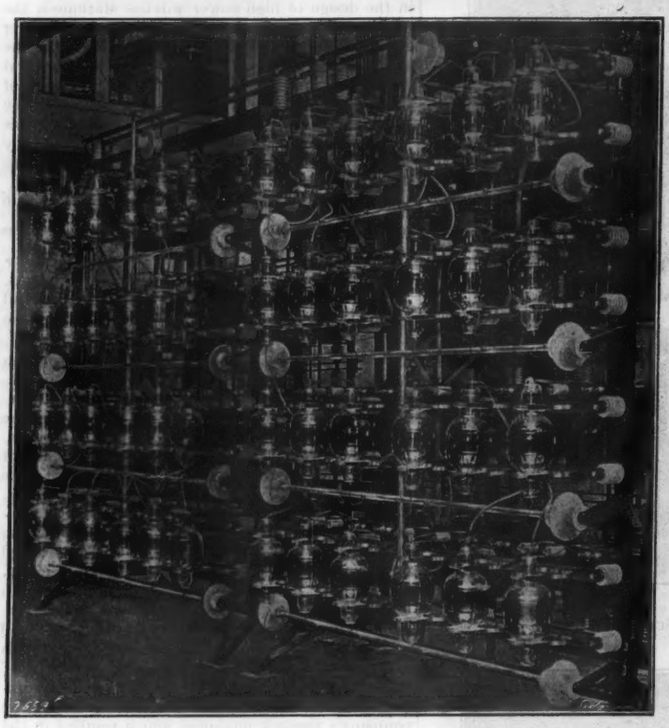


Fig. 6. Valve Transmitting Panel.

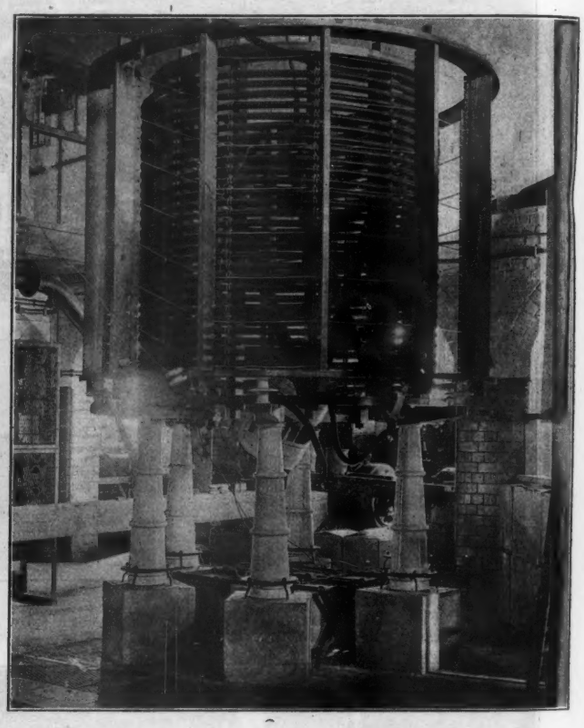


Fig. 7. Coupling Coil for Valve Transmitting Plant.

therefore, a Poulsen arc transmitter was installed as a reserve for the "timed-spark" transmitter in cases of emergency during the war period. This, however, was not found to be very satisfactory, as it was incapable of delivering more than 170 amperes to the aerial, and could not be worked for long periods without giving trouble. At the conclusion of the war, the commercial service with the United States of America was started up, using the "timed-spark" discharger that had been installed in 1916. The second set was delivered in 1919 and both machines gave excellent service. Incidentally it may be mentioned that it was with this transmitter that the first messages were sent direct from this country to Australia in 1918.

In 1920 improvements in receiving circuits were being rapidly made with a view to obtaining still greater selectivity and freedom from interference, and in order to take advantage of these improvements it became evident that it was necessary to employ a type of transmitter which produced a continuous wave of constant amplitude and freedom from harmonics. The valve transmitter, although giving excellent results on low-power stations, was not at this time sufficiently developed for high power use, the only other type of transmitter which would meet the requirements at all satisfactorily being the high-frequency alternator.

Alexanderson Alternator.—In order, therefore, to take full and immediate advantage of the improvements in reception, it was decided to install high-frequency alternators of the Alexanderson type without delay. In order that there should be no interruption of the commercial service an additional building was put up in which to install these machines and work was commenced in July, 1920. Two 200-kw. machines were delivered in September of that year and were installed and under test in April of 1921.

These machines are of the inductor alternator type, with solid steel rotors having 610 radial slots cut in each side of the rim, the slots being filled in with non-magnetic material in order to reduce the windage losses. The armatures are built of laminated iron strip, 0·0015 in. in thickness, enamelled on each side to avoid eddy currents, the armature slots being cut in the faces between which the rotor rotates, and the gap between rotor and stator being 0·035 in. The rotor is maintained in a fixed position by the use of equalising levers, having an adjustable controlling bar between them, which exert a thrust on each end of the shaft; and by the same device wear of the thrust bearing on each side of the rotor is automatically taken up.

The bearings and thrust bearings are lubricated by pressure feed at 15 lb. per square inch from a pump, chain-driven from the gear shaft, oil being supplied, during periods of starting and stopping, by a separate motor-driven pump. Water cooling is provided for the bearings and also for the armature, copper tubes for this purpose being let into faces of the latter next to the field frame.

The alternator is driven by a 420-b.h.p., 2,200 volts two-phase motor through a double-helical gear of ratio 2·973 to 1, flexible couplings used between motor and gear and between gear and alternator. For a wave-length of 14,000 m. the alternator runs at 2,109 r.p.m., and as wave-length is inversely proportional to speed the latter must be held within very close limits.

To obtain the close regulation which is necessary, one of the alternator armature coils is used for speed regulation. This coil supplies current to a capacity-inductance circuit having a resonance frequency slightly higher than the required alternator frequency. Working at a point on the steep part of the resonance curve of this circuit, the current rises or falls rapidly, due to a change in alternator speed. A small proportion of this current is drawn from the circuit through a magnetic coupling, and by means of a rectifier is made to operate a relay which controls variable impedances in the motor circuit. These variable impedances in the phases of the motor circuit consist of coils wound on an iron yoke, the iron being more or less magnetised by direct-current current supplied by a generator the fields of which are controlled by the above-mentioned relay.

With maximum field on the generator, the direct-current current supplied to the impedances, or "saturation coils" as they are termed, is sufficient to saturate the iron, and the inductance of the alternating-current winding is a minimum; and with no field on the direct-current generator the inductance is a maximum. In order to compensate for the signalling load relays working synchronously with the signalling key are also provided to cut out resistance in the rotor circuit of the motor, and also to reduce the impedance in the stator, the amount of "compensation" being adjustable to suit the load on the alternator.

Signalling is effected by means of a variable impedance, known as the "magnetic amplifier" shunted across part of the secondary winding of the transformer connected between alternator and aerial circuit. The variation of impedance of the amplifier is obtained by varying the magnetisation of the iron on which the shunt coils are wound, a separate winding supplied with direct-current current at 240 volts being used for this purpose. The minimum impedance is given by a current of 20 amperes in the direct-current winding and maximum impedance by no current in the direct-current winding. The signalling key consequently breaks and makes a direct-current current of 20 amperes at 240 volts for "marking" and "spacing" respectively.

Valve Panel.—These machines have given very satisfactory service for the past twelve months. With the introduction of very low damped "filter circuits" for receiving and the consequent greater necessity for constancy of wave-length, it was considered desirable to employ the valve transmitter which, since the installation of the alternators, has been developed at the station for high power use.

This type of transmitter very well satisfies the requirements of modern receiving apparatus. It emits a pure wave of constant wave-length, permits of a high rate of signalling and combines constancy of wave-length with high efficiency and low running costs. Moreover, unlike those transmitters which employ for the production of oscillations complicated machinery which must be installed in duplicate to ensure continuous service, duplication of the oscillation generator in a valve transmitter is unnecessary. The reason for this is that the generator panel consists of a large number of comparatively small units in parallel, the failure for any reason, of one unit not materially affecting the output of the generator as a whole, permits replacement of the unit at a favourable opportunity.

Fifty-six valves of the type known as M.T.2 are provided on the main panel, which consists of an iron framework with clips for holding the valves, and on which are mounted also the condensers and resistances for the grids of each valve. The filaments of the valves are connected two in series, the current taken by each pair being 10 amperes at 40 volts, the centre point of the series connection being earthed. The panel is shown in Fig. 6, on page 134.

The potential changes on the grids of the main valves necessary to produce oscillations are controlled by a separate circuit, which is maintained in oscillation at the desired frequency, energy from this circuit being transferred to the grid circuit of the main panel through an electromagnetic coupling. The anodes of the main valves are connected to one end of a winding which couples to a circuit containing an air condensing inductance coil, variometer and coupling coil, the latter transferring energy from the closed circuit to the aerial. The coupling coil is shown in Fig. 7, page 134.

The other end of the anode coil is connected to a source of high potential and the action of the transmitter as a whole is as follows: Direct current at 10,000 volts is fed to the anode circuit of the controlling valves. This circuit, which is in resonance with the main circuit frequency, is set into oscillation by the usual "reaction" between anodes and grids, and by means of the coupling potentials from this circuit are transferred to the grids of the main valves. The anode circuit of the main valves being fed with direct current at 10,000 volts, these variations of potentials on the grids produce oscillations in the main circuit, the energy from which is transferred to the aerial through the coupling provided. The 300-kw. generator which is the source of the 10,000-volt direct-current supply is shown in Fig. 8 annexed.

Signalling is at present effected by short-circuiting a resistance connected between the direct-current machines and the anode circuit of the main panel, an air blast being provided to extinguish the arc which is formed on opening the key. This method of signalling permits of a speed of 85 words per minute, but arrangements are being made for the keying to be done in the controlling circuit, which alteration will enable the speed of signalling to be easily doubled.

This transmitter is now being used to handle traffic with New York, the signalling keys being

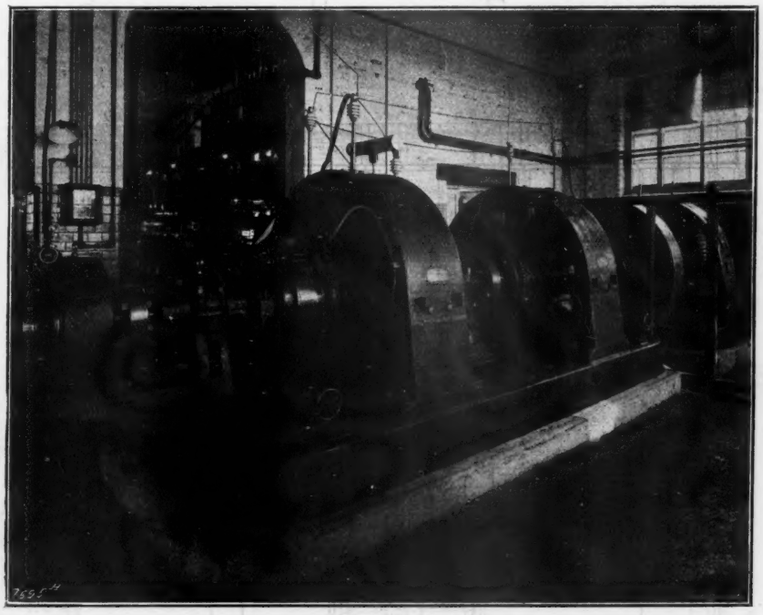
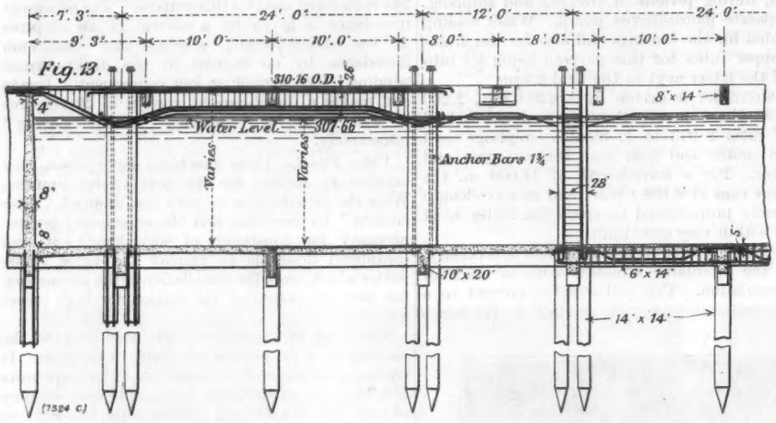
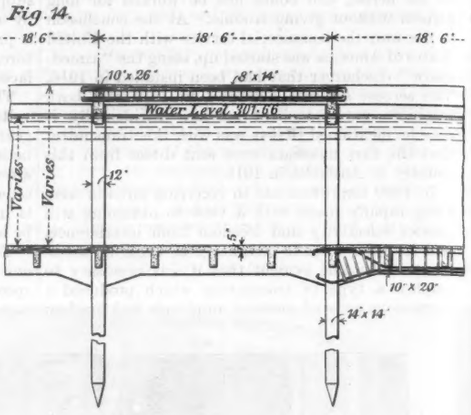


FIG. 8. 300-K.W. 10,000-VOLT DIRECT-CURRENT GENERATOR FOR SUPPLYING CONTINUOUS-WAVE VALVES.

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

MR. R. A. CHATTOCK, M.I.E.E., CITY ELECTRICAL ENGINEER.





operated by a Post Office type B relay. By means of change-over switches, this relay may be operated either by a hand key or Wheatstone transmitter at this station for testing purposes, or by the Wheatstone transmitter at the operating station at Towyn, one of two metallic loops connecting the two stations being used for this purpose. The second loop is used for a telephone circuit on which is superimposed a simplex telegraph circuit for convenience in handling service messages between Carnarvon and other offices.

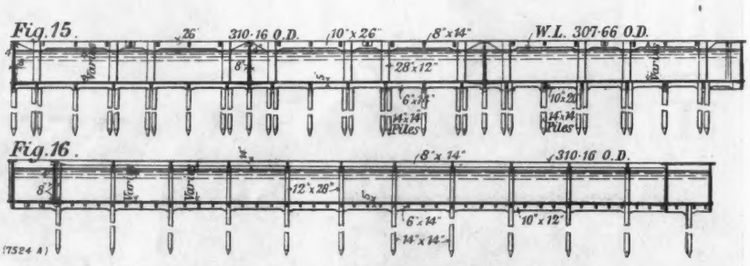
(To be continued.)

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

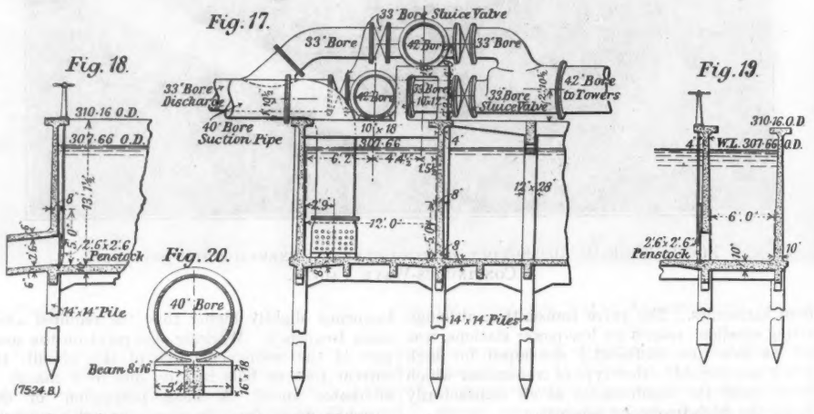
By W. NOBLE TWELVETREES, M.I.Mech.E., A.M.I.E.E., M.Soc.C.E. (France).

(Continued from page 102.)

DETAILS of the cooling-pond construction are given in Figs. 13 to 16, annexed. Figs. 13 and 14 illustrate the method of reinforcement used for the beams, while two cross-sections, at right angles to each other, through one of the ponds, are given in Figs. 15 and 16. The sides of the ponds consist of vertical slabs, 13 ft. high by 8 in. thick at the bottom and 4 in. thick at the top, strengthened by counterforts carried up from the foundation piles, and by horizontal beaming at the top, where provision is made as required for the support of the discharge pipes and valves. The depth of water in the ponds is about 10 ft. 6 in., thus giving a very large storage capacity. Additional piles have been driven for the support of the cooling towers, 106 ft. high, and from the head of the piles columns 12 in. by 18 in. in cross-section have been built up to carry the towers. Along the engine-house side of the ponds, there is a suction culvert about 12 ft. 6 in. wide by 13 ft. deep, provided with five sumps, 10 ft. deep below ground level and 10 ft. by 12 ft. in cross-section. These sumps are connected with the engine-house by underground suction pipes, a cross-section of one of which is given in Fig. 20, annexed. Details of one of the pipe-work connections to the towers are given in Fig. 17. Along the upper end of the ponds and along part of the River Rea side, there is a discharge culvert, 13 ft. deep by 6 ft. 4 in. wide inside, into which any of the ponds can be discharged through sluice gates, as necessary for cleaning or other purposes. A section through the culvert showing one of the sluice gates is given in Fig. 19. The discharge culvert empties into the sewer through a penstock at the end of the boundary line next the sewage farm filter beds. The outlet end of this culvert is shown in Fig. 18. The ponds and all structural details in connection are in reinforced concrete, the whole in monolithic connection and capable of acting on the single-unit system. Thus



FIGS. 13 TO 16. DETAILS OF COOLING POND CONSTRUCTION.



FIGS. 17 TO 20. DETAILS OF CULVERT PIPES AND VALVES IN CONNECTION WITH COOLING PONDS.

they would be capable of distributing very heavy loads at a safe and uniform rate over any soil of average stability without the aid of the piles which are necessary at Nechells owing to the exceptionally poor nature of the ground.

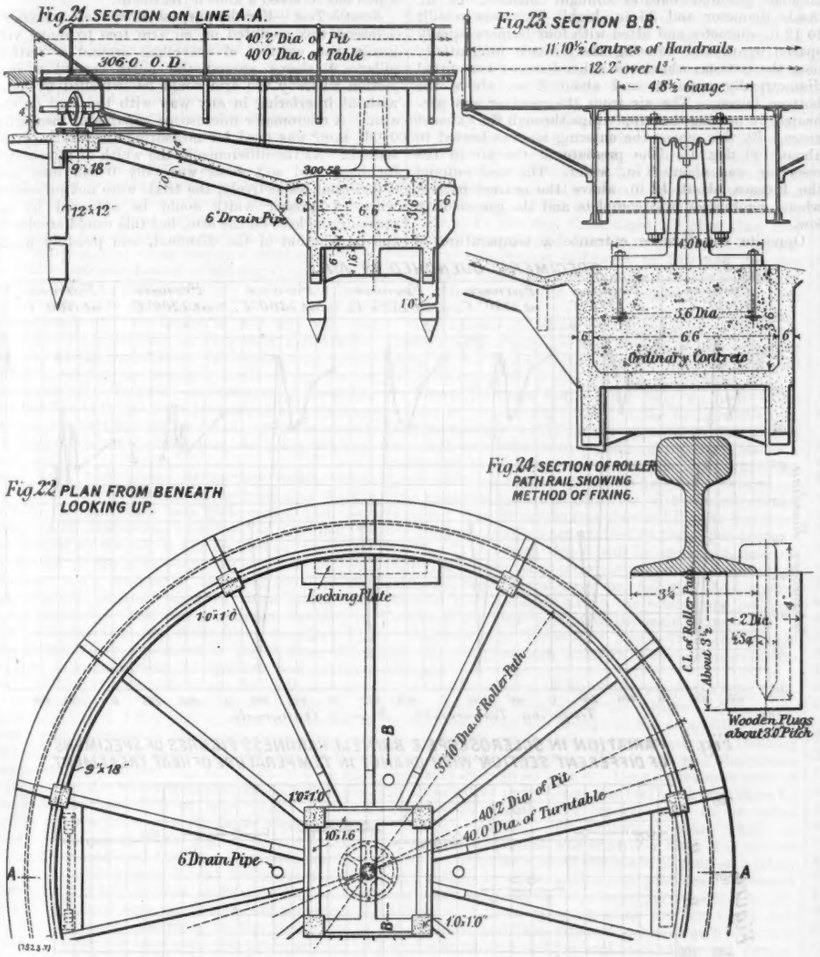
Chlorinating House.—Near the end of the power-house; and a few feet away from the front of the cooling ponds, there is a structure in reinforced concrete consisting essentially of a tank, 48 ft. long by 24 ft. wide by 15 ft. high, divided into several compartments by partition walls with suitable openings. Its position is shown in Fig. 3, on Plate VI. of our issue of January 26. A meter chamber adjoins the tank, and the whole structure is supported on a reinforced concrete foundation raft, 6 in. thick, with beams spaced about 6 ft. apart, beneath the raft being piles driven down to the sandstone formation. The tank is intended for the treatment of water drawn from the sewage filters and afterwards pumped to the cooling ponds.

Railway Turntables.—A short distance beyond the end of the power-house there is an interesting application of reinforced concrete in the form of a 40-ft. diameter railway turntable pit. The foundations consist of 14 piles arranged suitably for the support of a circumferential ring beam, 9 in. by 16 in., and four piles in the centre for the support of the base carrying the pivot of the turntable. The central base and the circumference of the pit are connected by radial beams, 6 in. by 12 in., and a continuous 4-in. slab. Cantilever brackets project beyond the ring beam for the support of the curb, which is 4 in. thick and finished level with the top of the turntable by circumferential coping. Details of this turntable pit are given in Figs. 21 to 24, on page 137. The 13-ft. diameter turntable pit previously mentioned in connection with the switch-house is of similar construction.

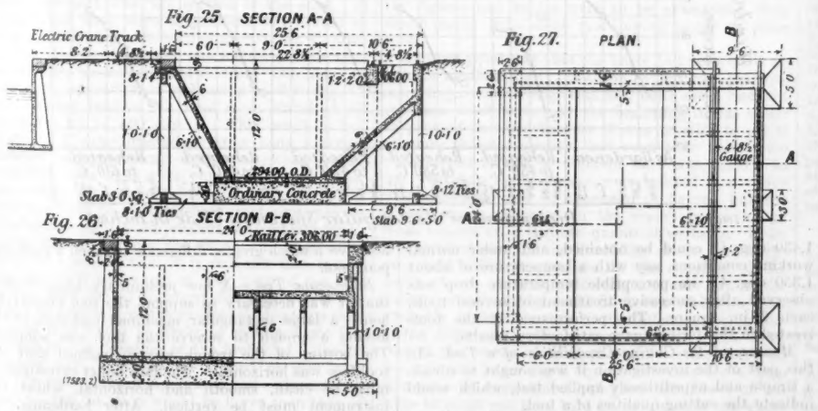
Coal Storage Pits.—Provision is made in the complete scheme for eight coal pits outside the canal front of the boiler-house, five of the pits having been constructed at present. Each pit is 24 ft. wide parallel to the boiler-house front by 25 ft. 6 in. from front to back at the top, the walls sloping down

THE NECHELLS POWER STATION, BIRMINGHAM.

MR. R. A. CHATTOCK, M.I.E.E., CITY ELECTRICAL ENGINEER.



FIGS. 21 TO 24. DETAILS OF 40-FT. DIAMETER RAILWAY TURNTABLE PIT.



FIGS. 25 TO 27. DETAILS OF COAL STORAGE PITS.

so as to make the corresponding dimension at the bottom 9 ft., the depth being 12 ft. below the level of a railway track passing over the whole range of pits, and carried by reinforced concrete beams. The bottom of each pit consists of a 6-in. slab resting on a plain concrete foundation slab. The sloping walls and the vertical end walls are 6 in. thick, stiffened by counterforts. Columns for the support of the beams carrying the railway track and other columns for the support of the top of the walls are built up from extended bases of the usual type, piles having been found unnecessary at this part of the site for the load to be sustained. The pits were built at original ground level, or slightly below it, the coping at the top being at the level to which the ground has been made up by filling. The position of the pits is indicated in the general plan given in Fig. 3, mentioned above. Some details of one of the pits are shown in Figs. 25 to 27, annexed.

(To be continued.)

LATHE TOOLS RESEARCH.

AT a meeting of the Manchester Association of Engineers on the 26th ult., Mr. Dempster Smith presented a *résumé* of the report of the Lathe Tools Research Committee.

In opening the proceedings the President, Mr. Daniel-Adamson, said he was a member of the original committee which reported in October, 1903. The series of investigations to be reported upon that evening commenced in 1914, and an interim report was read, though not published, in 1916. Since then the research had been supported by the Department of Scientific and Industrial Research. Thanks to the Chairman of the Committee, Mr. Chas. Day, they had enjoyed during the intervening period the full confidence of that Advisory Committee, and it had been expressed by financial grants, and finally by the publication of the present report by H.M. Stationery Office. The importance of the experimental work was recognised by a Government Department during the war, the use made of the results achieved materially contributing to the success in one section of our maritime activities. From the report, which covered a period of nine years' work, it would be gathered that some problems had actually been solved, but the progress made lay chiefly in the preparation of the ground for the many more problems that cried for investigation. One item in particular upon which some advance had been made was the laying down of conditions essential to the successful treatment of high-speed steel, and those, as he read them, were first, a high and uniform temperature of 1,320 deg. C. of the tool, with a subsequent reheating to 580 deg. C. Engineers would realise that previously the tendency had been not to treat high-speed tool steel at a sufficiently high temperature to obtain the best results. Reference was also made in the report to the scleroscope readings, which he understood had been helpful in the investigations, though they had not proved a definite guide as to the cutting efficiency of different grades of tool steel.

Mr. Dempster Smith then read a *résumé* of the report. We print the first part of his remarks below, but that relating to tool forms is omitted, as we deal with the matter elsewhere in our columns this week. It should be mentioned that for the figures which accompany Mr. Smith's remarks, numbers corresponding to those which appear in the full report have been retained.

Mr. Smith said results of the trials made by the Manchester Committee in 1903 received wide publicity and set other experimenters to work on extending the scope of that inquiry. The results obtained by the latter varied considerably, and opinion was expressed that the Committee should resume the inquiry over an extended field. In April, 1914, Mr. E. G. Miller, President, Dr. E. Hopkinson, ex-President, and Mr. Charles Day, past-President, acting on behalf of the Council of the Manchester Association of Engineers, communicated with Alderman Sir T. T. Shann, Chairman of the Education Committee, requesting the Governing Body of the College of Technology to grant facilities such as were given in 1902 to enable further experimental research to be carried out on cutting tools. This request was duly granted, and a committee was formed to draft a programme of work and control the investigation.

With the object of avoiding the useless repetition of work which had already been done, the committee decided that a report be prepared on past experimental work on lathe cutting tools. This was prepared by Mr. Dempster Smith and presented to the Association in March, 1915. The report revealed a wide diversity of opinion on many points, and a number of important points which had not been investigated.

The committee, therefore, decided on the following research: (1) To obtain a reliable method of heat-treating lathe tools of high-speed steel which could be accomplished without unusual skill on the part of the operator, and which would result in the tools being uniform in quality; (2) to obtain some simple means of testing the cutting capabilities of a tool without subjecting it to an actual cutting test; (3) to ascertain the variation in the durability of tools with change in the cutting speed, shape of tool, depth of cut and traverse, &c., when operating on medium steel; (4) to determine the forces acting upon the tool and the power consumed under different cutting conditions.

Heat Treatment.—Bearing in mind that a long series of tests was intended, it was essential that the committee should find a method of heat treating the tools which would give consistently uniform results under constant conditions, otherwise the results of trials under different conditions would not be comparable. In order that this result might be most easily accomplished, it was decided to use one grade of high-speed steel, the composition of which is as follows: carbon, 0·65 per cent.; chromium, 2·97 per cent.; tungsten, 13·08 per cent.; vanadium, 0·52 per cent. In this preliminary investigation a constant shape of tool was

adhered to. This tool was made from 1½ in. square section steel, had ¼ in. nose radius, and a cutting angle of 70 deg., measured in a plane 45 deg. to the length of the tool, this being approximately the plane of shaving.

First Method.—The tools were forged and ground to shape, preheated in the low-temperature chamber of a two-stage gas-fire furnace at 820 deg. C., and transferred to the high-temperature chamber at 1,275 deg. C., where they remained just long enough to produce a bright glowing strip about ⅛ in. wide along the cutting edge, afterwards being quenched in molten metallic salts at 250 deg. C. In the high-temperature chamber a baffle was placed opposite the gas inlet. The back of the tool was presented to the incoming gases and slightly turned round to present the cheeks, and as the process neared completion, the nose was brought behind the baffle.

Tools so treated gave good results in the first test, but the subsequent performance of these after being re-ground was not equal to the original. This result was contrary to the experience of many who had an extensive knowledge of this subject, the general opinion being that a tool which had been re-ground after failure gave a better result than in the first instance. The opinion of many experienced hardeners was obtained, and these indicated that the tools had been treated too delicately and at too low a temperature in the high-temperature chamber.

Second Method.—The tools were pre-heated as before, but the high-temperature chamber was raised to 1,320 deg. C., and the tools kept in this until a cluster of glowing specks appeared on the face of the tool about ½ in. from the nose.

In the high-temperature treatment there appeared to be four visible changes in the condition of the surface of the steel: (1) The glowing stage at the cutting edge is preceded by bright glowing specks, about the size of a pin point, appearing round the extreme edge, and these merging into one another produce a glowing strip. (2) Almost simultaneously with the appearance of this strip bright specks (about ⅛ in. diameter) appear immediately behind the former, and these travel backwards across the face in a cluster about ⅛ in. wide. (3) The metal immediately behind this moving cluster of glowing specks seems for a time to be in a quiescent state. (4) Ultimately the last-mentioned surface appears to rise like a bubble, generally bursting at the cutting edge.

The best results with these tools were obtained at that part containing the glowing specks or blisters at the time of cooling. These trials indicated that the portion of the tool in front of the glowing specks had not been sufficiently heated, and that behind had been overheated.

Third Method.—An effort was made to obtain conditions which would ensure the minute blisters being diffused across the whole surface and the nose being uniformly heated throughout. This was occasionally obtained with the furnace in use, but the process demanded considerable manipulation of the tool, and could not always be achieved. With a modified furnace the operation was considerably simplified, and consistency of heat treatment easily obtained.

The treatment finally adopted was to forge and grind the tools to shape, pre-heat to 800 deg. C., transfer to high-temperature furnace, about 1,350 deg. C., where the temperature of the nose rose to about 1,320 deg. C. At this temperature the surface of the tool is covered with bright glowing specks and appears to be in a state of mild ebullition. After cooling in an air blast the tools were re-heated to 580 deg. C., maintained at this temperature for an hour, and allowed to cool in still air.

The preliminary trials in the old furnace indicated that most favourable conditions prevailed where the heating was largely effected by radiation from uniformly heated surfaces. In the original furnace there was but one burner, and the air pressure required to consume the gas efficiently had to be about 1½ lb. per square inch. Independent control of gas and air seemed desirable in order to obtain a neutral or reducing flame for different gas qualities and pressures.

Modified Furnace.—There was available a disused circular gas-fired natural draught furnace, 18 in. inside diameter and 36 in. high. This was rebuilt to 12 in. diameter and fitted with four burners equally spaced apart and entering the furnace tangentially near the bottom, whilst two other burners were fitted diametrically opposite and about 3 in. above the bottom burner. The air from the receiver was pre-heated by passing the supply pipe through the exhaust gases. By this means the entering air was heated to about 100 deg. C. The pressure of the air in the reservoir was about 8 in. water. The tool entered the furnace about 12 in. above the nearest burner, where combustion was complete and the gas velocity low.

Opposite the furnace entrance a temperature of 1,430 deg. C. could be obtained, and under normal working conditions, say with a temperature of about 1,350 deg. C., no perceptible temperature drop was observed after successive treatment of several tools, each 2 in. square. The performance of the tools treated in this furnace gave satisfactory results.

Measure of the Cutting Capabilities of a Tool.—In this part of the investigation it was sought to obtain a simple and expeditiously-applied test, which would indicate the cutting qualities of a tool.

Abrasion Test.—Failure is brought about by the abrading action of the shaving, due to the combined effect of the pressure and speed on the tool face. It would appear, therefore, that an abrasion test would most likely provide a measure of the durability of the tool. With high-speed steels abrasion usually takes place when the nose of the tools is at a high temperature, yet it is possible that the observed resistance to abrasion when cold will bear some relation to that when hot.

In the abrasion test, where a diamond is used to scratch the face of the specimen, the period of time required to prepare it for the test, together with the constantly changing condition of the diamond with use, are distinctly against its adoption as a workshop test. Nevertheless it was decided to apply this test, and simultaneously to investigate the relation between the scratch width and hardness readings, such as those given by the scleroscope on several grades of tool steel which has received a known treatment.

Scratch Test.—For the purpose of this test a glazier's diamond was mounted on an arm free to move vertically and capable of swivelling around a vertical pillar. A sleeve around the pillar carried a projection whereby the arm could be swivelled by hand without interfering in any way with the load on the arm. A micrometer microscope capable of measuring 0·001 mm. was used for measuring the width of the scratch. As the difference in the width of the scratch for hard and soft tools was only 0·043 mm. and 0·055 mm. respectively, the trials were not proceeded with. A greater width could be obtained by increasing the load on the arm, but this would accelerate the destruction of the diamond, and possibly would not give a much greater difference between a good and poor tool.

Scleroscope Test.—A few preliminary trials showed that it was necessary to support the tool effectively, hence a large rectangular machined cast-iron block, having a trough to receive the tool was adopted. The bottom of the trough was so inclined that the tool face was horizontal. The face under investigation must be clean, smooth and horizontal, whilst the instrument must be vertical. After hardening, the tool is slightly pitted and small pieces of scale adhere to the surface. This scale must be removed, as it yields or breaks up under the scleroscope hammer, and the recoil is consequently less than that given by the solid metal.

Tests made on tools which had been hardened, forged and annealed indicated that the scleroscope figure generally rose and fell with the cutting capabilities of the steel. Fig. 4 shows the cutting performances of tools in different conditions as ordinates with abscissæ of scleroscope readings. The difference in the scleroscope reading corresponding to the above difference in scratch width was 28, but the scleroscope figure near the cutting edge was lower than that

VARIATION IN CUTTING PERFORMANCE WITH SCLEROSCOPE READING.

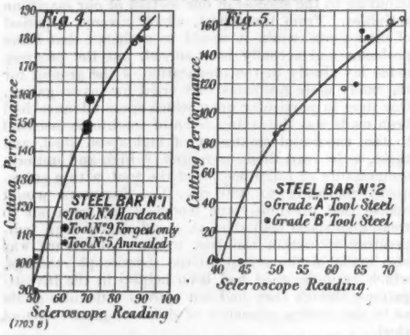


Fig. 6. SPECIMENS QUENCHED IN AIR.

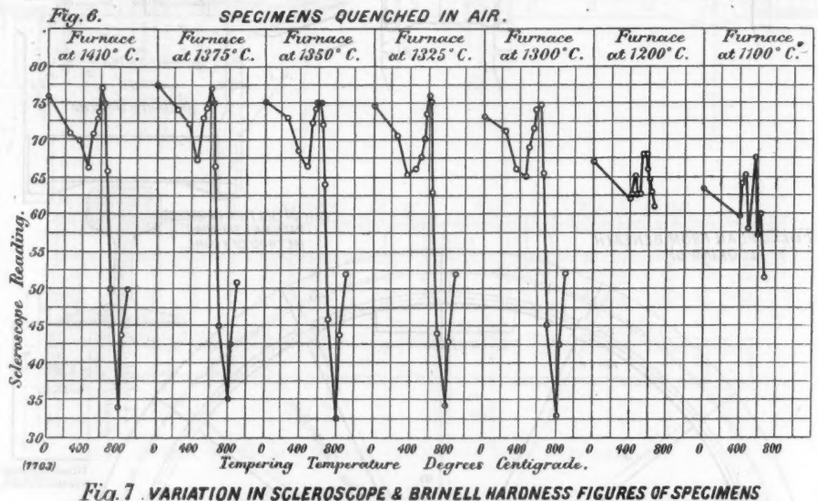
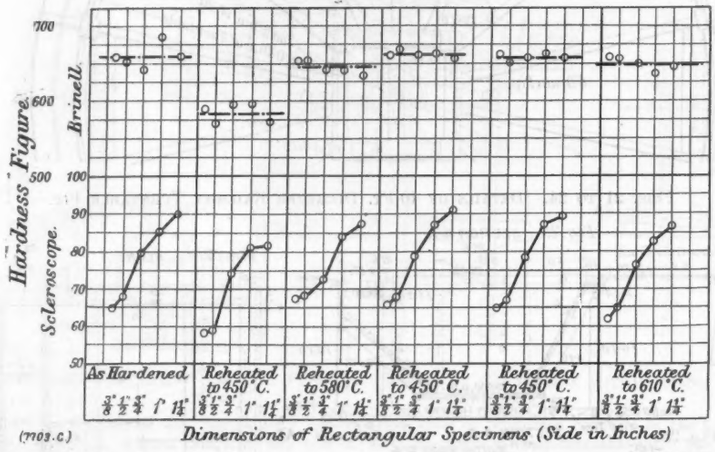


Fig. 7. VARIATION IN SCLEROSCOPE & BRINELL HARDNESS FIGURES OF SPECIMENS OF DIFFERENT SECTION WITH CHANGE IN TEMPERATURE OF HEAT TREATMENT.



obtained near the centre of the nose. A doubt existed as to the same scleroscope figures obtained on different steels indicating the same cutting capabilities. To put this to test, two steels referred to in the report as A and B were heat-treated, and the results obtained have been plotted on Fig. 5, from which it will be observed that the highest scleroscope figures for A and B are 72 and 66 respectively, whereas the highest figure obtained for the standard steel was 90. Although the maximum cutting performance of the tools A and B is only about 160, as against 190 for the standard tool shown in Fig. 4, the difference is due to the material operated on; and when allowance is made for this, the tools of steel A are quite as good as those of the standard steel. This appears to indicate a different scleroscope scale for different steels.

With regard to steels A and B, tools having a cutting performance in the neighbourhood of 160 were hardened in the usual way; those having a performance of 120 were simply forged and allowed to cool from the forging temperature; those having a cutting performance of about 90 were heated to 825 deg. C. and allowed to cool in still air; whilst the two tools which failed to pick up the cut were hardened in the usual way and tempered for two hours at 650 deg. C. The results are of importance, in that they indicate the extent to which the cutting performance of a tool may fall away once the properly hardened portion has been ground off. To guard against such a possibility it is advisable that the tools be marked at a distance back from the cutting edge, say 3 in., and re-hardened, when a certain amount of the tool, say ¼ in., has been ground away.

Since tools had given satisfactory results when tempered at fairly high temperatures, and having regard to the fact that two tools which had been hardened and afterwards tempered at 650 deg. C. failed to pick up the cut, it was decided to investigate with the aid of the scleroscope the effect of different hardenings and tempering temperatures for the standard grade of steel used in these trials. For this investigation a short tool was drawn out to ⅜ in. square section, and cut into short lengths. The results of these tests are shown in Fig. 6, from which it will be observed that for furnace temperatures below 1,300 deg. C. the results are decidedly irregular and unsatisfactory. The specimens hardened at temperatures above 1,300 deg. C. show a decrease in hardness with increase in tempering temperature up to 450 deg. C.; beyond this an increase with increase in temperature up to 600 deg. C., when it is as high as when hardened; whilst from 600 deg. C. to 800 deg. C. the hardness figure falls off very rapidly. Having regard to the abruptness of the latter change it was decided to investigate if 600 deg. C. was the critical point, and it was found that the maximum hardness was obtained with a second heat treatment for such specimens lasting half-an-hour at 600 deg. C., but that there was a distinct time lag, which had the effect of giving the maximum hardness to the specimens at 580 deg. C., when the treatment was prolonged for an hour or more, and it was found later that the duration of the treatment for maximum hardness at this temperature increased with the section of the steel. It was also found that when a specimen was heated to 450 deg. C. following a re-heating at 600 deg. C. after hardening, that the hardness was identical with that obtained with specimens cooled from 600 deg. C. It, therefore, appears that re-heating to 600 deg. C. after hardening renders the steel more stable at all temperatures up to 600 deg. C. This result is important, and if substantiated by other tests a partial explanation is forthcoming of the somewhat erratic behaviour of some tools when cutting.

A tool which has been cooled from about 1,320 deg. C. and not subjected to a second heat treatment may be raised when cutting to a temperature of about 600 deg. C. for some distance across the face. On re-grinding the tool for a second trial it is probable that a new cutting edge will be formed at that part of the tool which had been heated to about 600 deg. C. If the resistance to wear follows the hardness indications then the second trial would be likely to show a slight improvement on the duration of the first trial. Should the cutting edge, however, be formed at that part of the tool where the temperature had only reached 450 deg. C., the duration would be lower than that of the first trial.

It would seem that when cutting at a high speed with a tool which has been simply hardened, its temperature would be gradually raised and the rate of wear as it passes through the lower temperature range (up to 450 deg. C.) would be greater than in the case of a tool which had received a suitable second heat treatment.

Tests on specimens having different cross-sectional areas.—Having regard to the fact that when scleroscope hardness readings were taken across the face of the tool in a direction at right angles to the tool length, the readings increased as the centre was approached, it was decided to make tests on specimens of different cross-sectional area in order to determine to what extent the section of the specimen affected the hardness figure.

The results are shown in the order in which the treatments were made (reading from left to right) in the lower half of Fig. 7, and the deductions which may be drawn from these may be briefly summarised as follows: (1) The scleroscope figure is influenced by the section of the specimen. (2) The temperature in the second heat treatment which gives the maximum hardness is about 580 deg. C., but the time required to effect the change in the structure increases with the section of the specimen. (3) The maximum hardness obtained after a second heat treatment is practically equal to that obtained by direct cooling from the high temperature in the first heat treatment. (4) The hardness figure of a certain specimen which has been re-heated to 450 deg. C. after being previously re-heated to 580 deg. C. is slightly higher than that obtained when heated directly to the latter temperature. (5) Specimens re-heated to 610 deg. C. give a slightly lower hardness figure than the maximum, and indicate that the critical temperature has been exceeded.

The above variations in the scleroscope hardness figures with change in the section of the specimen account for the variations in the readings obtained at different points across the face of the tool.

Brinell Hardness tests.—Since fully an hour is required to prepare the surface of the tool for this test, and as the test would in any case injure the tool, it was not proceeded with. Although of little use as a workshop test for cutting tools, it was decided to apply it to the rectangular specimens in order to compare the hardness figures so obtained with the scleroscope figures. The Brinell figures obtained for the specimen of different sections are plotted in the upper portions of Fig. 7, and from this it will be seen that these do not vary with the cross-section of the specimen, although they generally rise and fall with the temperature of the treatment as do the scleroscope readings shown in the lower portion of the same figure.

Magnetic and Electrolytic Tests.—The tests made by these means were unsatisfactory and were abandoned.

At the conclusion of Mr. Smith's remarks, Mr. Chas. Day, speaking on behalf of the members of the committee, expressed the thanks of the committee to Mr. Dempster Smith for his unceasing energy extending over a number of years. The committee themselves had very little to do with it; their duties were more of a consultative nature, and the real work was done by Mr. Smith. Really this report ought to be called "Smith's Report." An important point which he wished to emphasise was that this work was not an attempt to create a lot of records in cutting on a lathe, but rather to determine some problems connected with cutting. Better results might possibly be obtained with tools by using some modern steels, but their efforts had been directed to arrive at tools which were reliable and uniform, and then to proceed further to learn lessons about the cutting power of tools made from that steel. It was from that point of view that the figures and tables were to be examined; they would apply with some multiplying factor to other tools.

Another point was that the trials had been made on mild or medium steel; cast-iron, which was, perhaps, more important to engineers and machinists, had not yet been dealt with. At the beginning it was easier to proceed on steel because it was possible to get it of more uniform quality, but even then there were wide variations due to different bars being used. In the workshop many lessons were learned in a vague way and could not be expressed in figures, but the investigations recorded in the report put some of these lessons on a definite quantitative basis. From the point of view of the durability of the tool workmen held different opinions on the question of the depth of cut, one man preferring a square cut, whilst another would say he could do better with thin cuts. Probably both were right; the difference being due to the difference in the power available on the lathe. One of the curves showed that the vertical force on the tool was lower for a square cut than for a deep thin cut. If a workman had good belt power on his lathe he could cut ½ in. by ⅛ in. as a square cut where he could not obtain the equivalent in a deep thin cut.

Emphasis had been laid on the advantages of uniformity. That was an important point. If results were jumping up and down they would not get very far; it was worse in a workshop than in laboratory trials. If in one department 20 tools were being used, and two of them would give a certain cut at, say, 40 ft. a minute, and then failed, while the others cut at 60 ft., it would be difficult in that shop to carry anything more than the 40 ft. The tool which failed impressed everybody much more than the tool which succeeded. Therefore the uniformity of heat treatment had received particular attention.

Replying to Mr. Day's remarks, Mr. Smith said it must not be supposed that the work was entirely or mainly his; on many occasions he had to seek assistance from members of the Association, and the information he wanted was always readily given. The work had afforded him intense pleasure; it was a hobby as well as work.

A NEW TYPE OF FURNACE ARCH.

THE ordinary form of furnace arch, as used with chain-grate stokers, works under extremely arduous conditions. The heat underneath it is frequently sufficient to start fusion of the bricks of which it is built, and the expansion and contraction of the latter with changes of temperature is another source of weakness. Moreover, a practical limit soon occurs to the width such arches can be built because of the limit to the rise of the crowns. Consequently large furnaces have to be spanned by two or more arches resting upon longitudinal division walls, and the maintenance of these walls is heavy owing to their destruction by slag and clinker. In order to avoid the difficulties inherent in the construction and maintenance of arches of the ordinary type, the Underfeed Stoker Company, Limited, of Coventry House, South-place, London, E.C.2, are introducing into this country a new form of arch, under the name of the Detrick-Usco suspended arch. It is not, strictly speaking, an arch at all, but as it fulfils the functions of one the name will serve.

The Detrick-Usco arch has no rise, but forms a flat or inclined roof to the furnace, which may be of any width required in practice. The construction is as follows. Several steel girders are carried transversely across the furnace, and from these are suspended by means of links, a number of longitudinal hanger-bars. The latter are of ⊥ section and each carries a row of firebricks, the bricks being suitably slotted and threaded over the flanges of the inverted tee-irons. The hanger-bars can adjust themselves transversely to allow for expansion movements of the bricks, and the bricks can slide longitudinally a sufficient amount to relieve stresses. The hangers are sectionalised so that any bricks which may melt or break can be replaced without much difficulty, and by using special bricks the longitudinal section of the arch may be made of any reasonable profile.

In addition to the advantages which are derived from the greater width and ease of repair of the Detrick-Usco arch, it is claimed that the flatness of the arch tends to greater uniformity of combustion of the fuel, and causes the gases to be discharged uniformly across its whole width. The construction, moreover, sets up no end thrust. Specially-shaped firebricks, of course, are required, in order that they may be suspended from the hanger-bars, but these no doubt could be readily supplied. The use of arches of the type in question is, of course, not limited to the furnaces of steam boilers, as the principle may equally be applied to furnace arches of any kind.

INSTITUTION OF NAVAL ARCHITECTS.—The annual meetings of this Institution will take place on Wednesday, March 21, and the two following days, in the Lecture Hall of the Royal United Service Institution, Whitehall, S.W.1. The annual dinner will be given on Wednesday, March 21, at 7.30 p.m., in the Grand Hall, Connaught Rooms, Great Queen-street, Kingsway, W.C. The council are arranging to hold a summer meeting of the Institution in Holland in September. A cordial invitation has been received from the Royal Institution of Civil Engineers at the Hague and the Nautical Technical Museum at Rotterdam, who will arrange for visits to be paid to the principal shipbuilding and engineering works at Amsterdam, Rotterdam and Flushing. Full particulars of the meeting will be given when the programme has been drawn up.

THE LATE PROFESSOR GEORG LUNGE.—Professor G. Lunge, formerly of the Zürich Federal High School, and who died last month, was for many years a leading authority on the chemical technology of acids and alkalis and acknowledged as such over here as well as on the Continent. Born in 1839, in Breslau, Lunge studied there, and later under Bunsen and Kirchhoff at Heidelberg. He became a chemical manufacturer on a small scale, and settled in South Shields in 1865 as a chemist, subsequently becoming manager of the Tyne Soda Works of Messrs. Bowron and Co. He gave this work up after eleven years, having been appointed professor of chemical technology at Zürich. In this chair, which he occupied for thirty-one years, till 1907, he had many distinguished colleagues, and he contributed himself much to the fame of the Polytechnikum, later known as Federal High School. He was a prolific writer. His first book was on the estimation of nitric acid. The first edition of his "Soda Industry," 1879, consisted of two volumes; the further editions comprised three bulky volumes. Lunge wrote the English versions of this work and of several of his other works. His smaller "Handbook of the Soda Industry" and his "Coal Tar and Ammonia" ran into five editions; most of his own researches were embodied in his "Methods of Techno-Chemical Analyses," of which six editions were published. His "Technical Gas Analysis," of 1914, was one of his last publications.

SPERRY GYROSCOPIC SHIP STABILISER.

Early in the present year, it is expected that sea trials will have been completed on the largest gyroscopic ship stabiliser so far installed on any vessel. The distinction of being the pioneer in applying the gyro-stabiliser to a light cruiser belongs to the Imperial Japanese Navy, which recently purchased from the Sperry Gyroscope Company, of Brooklyn, New York, a plant capable of eliminating all roll from a 10,000-ton ship. Specifications called for a plant capable of delivering a 4·7 deg. roll quenching power to a vessel of 10,000 tons deadweight, with a metacentric height of 3·35 ft., and period of roll of 12 seconds. The 4·7 deg. roll quenching power refers in a direct manner to the capacity of the stabiliser as measured in terms of the effect a single wave might have on the ship. The actual size of the gyro, however, depends upon the angular momentum necessary to produce such a roll-quenching power. This factor is given by the following equation developed from basic principles of Admiral D. W. Taylor, U.S.N.—

$$k^2 W R = 1225 Q \times D H T$$

in which k^2W is the inertia of the gyro about its spinning axis, R is the revolutions per minute of the gyro, Q is the roll-quenching power in degrees, and D H T is the product of displacement in tons, the metacentric height in feet and the period of roll in seconds.

For the Japanese Navy light cruiser the factor k^2W R is equal to 2,310,000,000. A rotor to give this value is 12½ ft. in diameter, and runs at 815 r.p.m. The speed of the rotor is limited to 32,000 ft. or 33,000 ft. per minute peripheral velocity, and the dimensional proportions are more or less fixed by design, so that there is little choice in selection of the rotor diameter. At the time this gyro was built it was impossible to obtain a forging of sufficient size and weight to make the rotor of one piece. The design finally adopted made use of two 12½ ft. diameter discs of forged 0·4 per cent. carbon steel bolted face to face and dowelled by a ring key in the outer rim of the wheel. This rotor is shown in Fig. 1, on Plate XIII, before the shaft stubs and balancing plugs were in place, and as shown weighs 139,000 lb. No difficulty was encountered in balancing the wheel and a 10 per cent. overspeed test showed no vibration. The tangential stress in the web is not over 13,000 lb., per square inch at normal speed.

Fig. 2, on Plate XIII, shows the assembled equipment under test in the works, while Fig. 3, on the present page, shows the rotating element being assembled in the casing. The casing is of cast steel, the centre part, enclosing the rotor, is made airtight, and the clearances between the casing and the rotating shafts are sealed by water glands. The centre casing is piped up to an air injector, and when in operation the rotor runs in a vacuum of about 24 in. Hg. The direct saving by this vacuum operation amounts to 90 h.p.

The spinning motor is a 200-h.p. three-phase induction motor, the rotor of which may be seen below the gyro wheel in Fig. 3. The stator coils are in the lower cone casing and are air cooled. The motor is able to accelerate the gyro from rest to full speed in 80 minutes. When installed on the ship, the stabiliser casing is supported in two gudgeon bearings so that the entire unit may swing fore and aft about a horizontal axis through the centre of the rotor. The velocity of oscillation, or precession as it is called, is determined by the period of roll of the ship, since the gyro must precess from the extreme position forward to the other extreme aft in the same time the ship rolls from starboard to port, or *vice versa*. The rate of precession is given by—

$$V = \frac{2 \cdot 2 \pi}{T}$$

where V is the angular velocity of precession in radians per second, and T is the period of roll in seconds. This value is 0·575 radians per second for the stabiliser in question, and it is maintained within 10 per cent. variation by a precession motor geared to the gyro unit through a spur-gear reduction train having a 100 to 1 ratio.

The gyroscopic stabilising moment is given by the equation

$$M = \frac{K^2 W R V}{307}$$

where M is the gyroscopic couple in pounds-feet, k^2W R is the momentum factor of the rotor, and V the rate of precession in radians per second. For a constant speed of the gyro rotor, the gyroscopic moment depends only upon the rate of precession, so that, by limiting the velocity of precession the designers have a means of limiting the couple which the stabiliser may exert on the ship. This dispels the common belief that the stabiliser matches pound for pound every force that is applied to the ship to make it roll. No matter how great the wave impulse the stabilising effect cannot exceed the normal couple as determined from the above equation. For the stabiliser in question this couple is 1,930 foot-tons. The forces are applied to the ship through the gudgeon bearings approximately 15 ft. apart. The maximum gyroscopic force is therefore less than 130 tons. Such a force is distributed over several frames and transmitted to the hull without the slightest difficulty.

The question of the fore and aft couple is an important one. It will readily be seen that the rolling of the ship will cause the stabiliser to exert a gyroscopic couple 90 deg. away from the plane of roll, and that this couple is in a direction such as to cause precession of the gyro unit in its gudgeon bearings. The magnitude of this couple is given by the same equation immediately above, but the quantity V now becomes the angular velocity of roll of the ship expressed in radians per second. The angular velocity of roll follows the cosine law very closely, being zero when the ship is at the extreme port or starboard position and becoming a maximum when the ship is passing through the upright position. The fore and aft couple therefore changes rapidly at the beginning and end of roll. At the beginning of the roll it assists the precession motor in accelerating the gyro unit to full speed of precession, and if the roll is over 2 deg. or 3 deg. it may actually tend to overspeed the motor. In this case the motor becomes a generator and pumps back into the line. The motor design is such that the speed is practically constant whether motoring or generating. At the end of the roll the fore and aft couple as well as the momentum of the moving parts, is absorbed by dynamic braking through the motor and by the application of a 21-in. diameter direct-traction elevator brake on the motor shaft. This combined braking effect stops the gyro gently in less than 1 second, and in a movement of about 5 deg. A second brake of the same type and size is used for emergencies when the fore and aft couple is too great for the motor to handle alone. When it is desired to stop stabilising for any length of time, both brakes are applied, and they will prevent all motion of the gyro unit in its gudgeon bearings.

The release and application of the brakes, together with the operating circuit for starting and stopping of the precession motor, are controlled from a small pilot gyro. This is shown in Fig. 4, on page 141. It is mounted with its spinning axis athwartship, and roll of the ship causes it to turn about a vertical axis, and thus make contacts which operate the control relays. As an indication of the sensitiveness of this pilot gyro it may be remarked that the relays operate within ½ second after roll starts. It is this instantaneous result which makes the stabiliser "active" in its operation.

The bearings of the main rotor are a departure from the usual practice. The radial bearings are 16½ in. by 24 in. babbitted sleeve bearings, with spherical seats for self-alignment. The load on these amounts to 825 lb. per square inch projected area. The peripheral velocity of the journal is 3,500 ft. per minute. Oil is supplied at 8 lb. to 10 lb. per square inch pressure, and is cooled externally, making water cooling of the bearing unnecessary. The gyroscopic loads traverse every face of the bearings, and vary from zero to a maximum. The maximum loads occur only on the athwartship axis of the bearings. These are the stabilising loads. The fore and aft force at its greatest is only about half the stabilising load, because the

SPERRY GYROSCOPIC SHIP STABILISER.

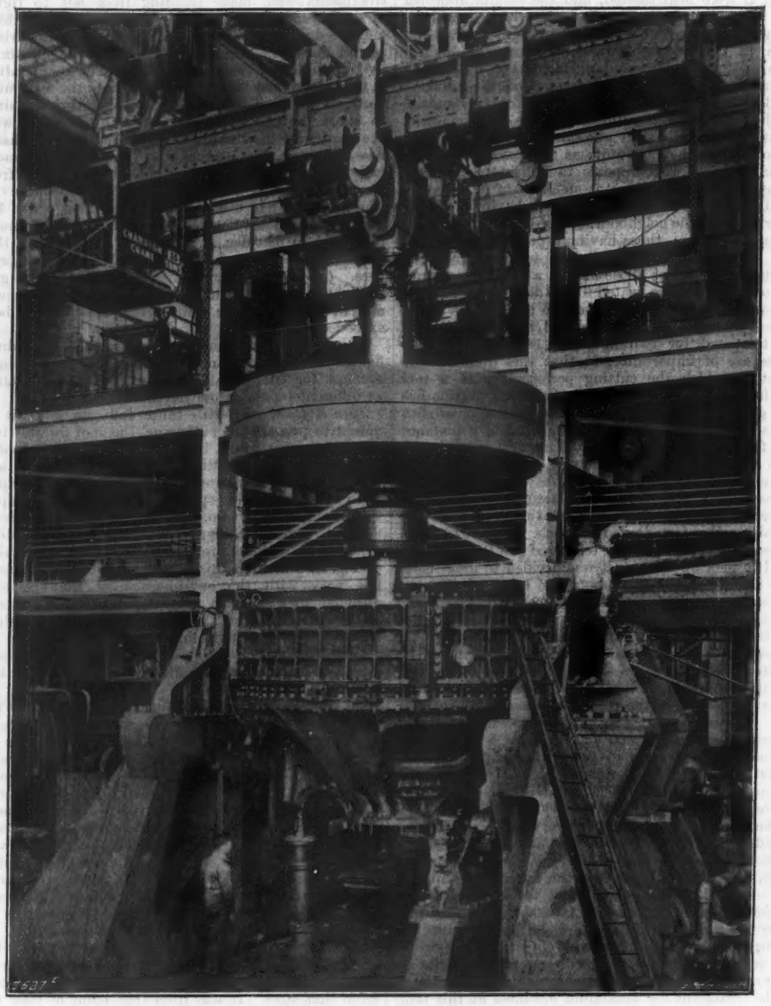


Fig. 3. Stabiliser in Course of Erection.

SPERRY GYROSCOPIC SHIP STABILISER.

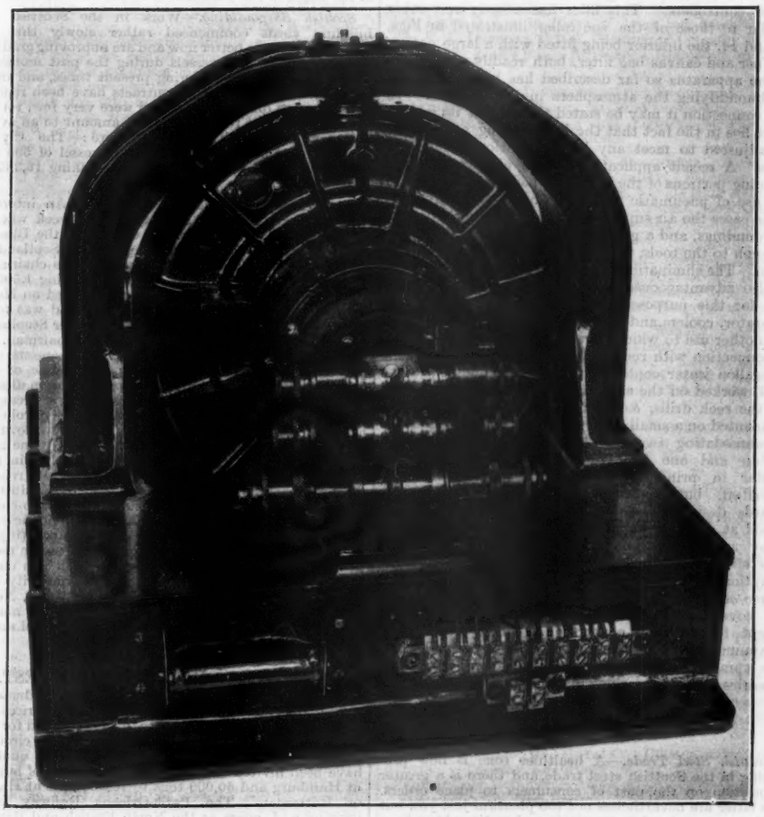


FIG. 4. PILOT GYRO.

velocity of roll is rarely more than half the precession of velocity. The rolling of the journal about the surfaces of the bearing works to advantage, since it permits periodic cooling of the surfaces not under load. A Kingsbury thrust bearing takes the gravity load of the rotating element. As it is impossible, because of the low power of the motor to start rotation of the gyro while resting on the Kingsbury bearing, the entire rotating element is lifted on to a roller bearing by means of a hydrostatic jack. The Kingsbury bearing is located in the lower cap below the lower cone casing, while the roller bearing and jack are in the corresponding position above the rotor. Only a few hundredths of an inch lift is necessary to relieve the Kingsbury bearing of the load, and the motor will then start at less than 1,000 lb.-ft. starting torque.

Power for operation of the entire equipment is supplied by a turbine generator set. Direct current for excitation and control circuits is supplied by a 12-kw. exciter. Three hundred and thirty volts direct current for the precession motor is supplied by a 110-kw. generator and 440-volts alternating current for the spinning motor by a 185-k.v.a. generator. When accelerating the gyro, the alternating-current motor and generator are connected in circuit, the turbine is started, and its speed rises gradually as the gyro accelerates, the load being maintained at any desired figure by the steam throttle valve. When the plant is in operation and stabilising, the positive and negative peaks of the precession motor loads are delivered through the direct-current generator to the alternating-current generator, and here appear as fluctuations in the alternating-current load of that generator. The spinning motor being coupled to a flywheel of great inertia, maintains constant speed unaffected by the rapid changes in the line current. All of the energy delivered by the waves through the fore and aft couple of the gyro is saved and used to maintain speed of the rotor itself.

Installation of the equipment was made at the Yokosuka Navy Yard, in Japan. The stabiliser was placed about midships just aft of the boiler room, the centre of gravity of the gyro unit being only a few feet below the water line, and therefore making very little change in the metacentric height. Except for the effect of the increase in displacement, which is small, the characteristic product D H T remained the same as before installation. In some cases the installation of the stabiliser on deck, or low in the hold, will so alter the metacentric height and period of roll that the roll-quenching power is materially reduced. For this reason the location of the stabiliser on the ship is a matter for consideration before design is completed. The location fore and aft matters little. The stabiliser applies pure torque, and the effect is the same no matter where the point of application is.

Although the ship was not prepared to go to sea at the time the installation was completed, a preliminary test of the stabiliser was carried out in still water. The ship was moored away from the dock. The gyro rotor was spun up to one-third full speed, and the equipment was used to roll the ship. During this process the main stabiliser gyro is 180 deg. out of phase with the roll of the ship, and is maintained so by a reversal of the control circuits from the control gyro. When a roll of 15 deg. total arc had been built up the stabiliser was stopped and the ship allowed to come to an even keel by its natural dying-down roll. Graphic records of this rolling were made on gyroscopic recorders. The ship was forcibly rolled a second time to the same angle, but this time the control circuits were reversed back to the stabilising condition so that the gyro could quench the roll. The difference between these two quenching curves gave the effect of the stabiliser, and afforded a means of checking up the equipment for agreement with contract terms.

Forced roll in excess of 15 deg. total arc is hardly to be expected with the present equipment. As explained above, the gyro tends naturally to stabilise the ship, but during forced rolling it is out of phase 180 deg. with the roll, and is kept so by the precession motor. When the passive fore and aft couple due to roll becomes large enough, it will overload the precession motor and cause it to slow down, thereby decreasing the velocity of forced precession. Finally, a balance will be arrived at wherein the output of the precession motor is exactly equal to the passive effect of the gyro, the precession speed characteristic will be uniform over succeeding cycles, and the forced roll will be uniform in amplitude and period. It is quite evident that the stabiliser can under no circumstances cause the ship to roll more than small angles.

AIR FOUNTAIN HUMIDIFIERS.

ALTHOUGH the air compressing, cleaning and humidifying apparatus illustrated in Figs. 1 to 14, on page 144, has been primarily designed and used in connection with the production of the degree of humidity in the atmosphere required for satisfactory operation in textile mills, its interest is of a rather wider character, since other uses have been found for it. The plant is constructed by Messrs. Herbert Smethurst and Sons, Limited, Stanley-road, Hollinwood, Lancashire, and consists of a complete compressor outfit with separators, coolers, filters and water regulators. In the system of humidifying by means of air fountains, compressed air is supplied to what is virtually a water atomiser, and an exceedingly fine mist of water or vapour is supplied to the atmosphere. The installation shown in Figs. 1 and 2 is capable of supplying 50 air fountains discharging from 250 lb. to 1,500 lb. of water per hour, and embraces a two-cylinder belt or motor-driven compressor. This compressor has cylinders 8½ in. by 10 in. stroke and runs at 350 r.p.m., at which speed it absorbs about 35 h.p. The belt-driven machine is provided with fast and loose pulleys, 36 in. in diameter by 7½ in. face.

The compressors used have either mechanical, or automatic suction valves. In both, arrangements are made for the governor to lift the suction valve off its seat when the desired pressure is obtained in the receiver system. Fig. 3 shows a section of the automatic suction design of compressor, and Fig. 4 gives a section of the valve and governor. Referring to the latter, the pipe *a* of the control valve is coupled to the receiver. At the bottom of this fitting is a chamber filled with filtering medium. Above this chamber is a spring-controlled valve *b*, which, when lifted off its seat, allows air at receiver pressure to pass into the pipe *c*. This pipe connects with the underside of the suction valve mounting, where it is admitted into a chamber containing a piston *d*. Fitted in this piston is a stem which branches above into a fork. The limbs of the fork are arranged under the plate suction valve, and when the fork is raised by means of the air at receiver pressure below *d* the suction valve is lifted off its seat, and the cylinder runs idle. A fall in the receiver pressure in the pipe *a* allows the valve *b* to return to its seat, and exhausts the air in *c*. Below the piston *d* there is a screw and hand-wheel enabling the valve to be lifted so that the compressor may be started without load, or, if full output is not required, any of a number of cylinders of an installation to be cut out.

The cylinders and valves are water jacketed, and great care has been given to the question of lubrication. The lubrication system embodies a rotary oil pump driven by belt off the crankshaft. Details of the pump are shown in Figs. 5 and 6. The oil is drawn from the base of the crank chamber through filter plates, and is delivered under pressure to the bearings and crank-pin. The pump is fitted with a regulating screw by which the amount of oil supplied to the bearings can be controlled; any excess is by-passed through the spring valve fitting shown in Fig. 6. A plunger type indicator is fitted which shows when the pump is working properly.

From the compressor the air is passed through cleaning apparatus. This comprises the coolers and filter-receivers shown in Figs. 1 and 2, though it is recommended also to include in the plant, as the first unit on the discharge side of the compressor, the oil separator shown in section in Fig. 7. On account of the heat generated in compressing the air, a certain amount of the lubricating oil is liable to be vaporised. To arrest this the air is passed up through a column containing cast-iron boxes with nests of tubes, constructed so as to provide a very tortuous path. Oil which settles on the baffle surfaces runs to the centre of the column and is allowed to pass to the base through a series of central tubes. From the sump in the base it is drained off by a pipe and cock.

Next follows the cooler unit. In the installation shown the air is branched through two double coolers. A section of one is shown in Fig. 8. Each column consists of a set of tubes through which the air is passed and round which water is circulated. It is essential, in order to obtain the regular operation of the air fountains, to remove all moisture from the compressed air. This is accomplished in the coolers, the water vapour condensing on the tube surfaces and being run off through a drain in the base. The water circulation will be followed in Figs. 1 and 2. The cooler is constructed so that the tubes can be easily removed. As in the oil separator, by slackening out two screws and loosening two clips, the cover of each column can be quickly removed. Inside this is a removable cross-bar. The tubes are fitted in tube plates each of which has a

conical face corresponding with conical seats in the column. Interposed between the faces is a ring of jointing material, and the tube plates are forced down on the seats by a set screw in the removable cross-bar. The cooling surface provided varies with the class of installation. In very small plants a single column suffices, and in such a case is mounted on a base identical with the base of the oil separator (Fig. 7). In fact, standardisation is carried further, for the actual column of the separator, and the domed top, are identical in design with those items of the coolers.

Before delivery to the humidifiers the air is stored in receivers, two of which, of 7 cub. ft. capacity, are shown in Figs. 1 and 2. A smaller pattern is also used, designed on similar lines, but arranged rather differently as regards the provision for filtering. The large pattern is illustrated in Fig. 9. The air enters in single units at the base, passes up through the filtering waste, packed between grids, and is led off through an outlet in the domed top. In the installation shown the air passes through the two receivers in series. A pressure gauge is fitted, and an automatic relief valve, while, as mentioned in connection with the compressor, a small air pipe is carried from the receiver to the compressor governor control. Large cleaning doors are provided in the side in this size of receiver. In the smaller size the dome cover is removable and the waste is contained in a basket which can be taken out for cleaning purposes.

From the receivers the air supply is carried to the water controllers and air fountain humidifiers. The water controllers are placed near the plant or close to where the air is used. The latest pattern of "Twone" air fountain made by Messrs. Smethurst is illustrated in Figs. 10, 11 and 12. Of these Fig. 12 shows the air and water connections and filters in section. The two connections are combined in a union fitting terminating in a circular flange fitted with two circular spigot rings. The fountain proper has a corresponding circular mating socket flange. The joints between the two are made with packing rings and the fountain may be set by this arrangement to discharge in any desired direction. The air and water enter at the top and, traversing this flanged joint, pass down to two limbs, the upper parts of which are sectioned in Fig. 12, the lower part being shown in section in Fig. 10. From here horizontal passages communicate with the body of the filters, and passing up through these the air from one and the water from the other meet at the nozzle shown in Fig. 11. The filters are copper cages surrounded by fine copper gauze. The air is brought to the nozzle into a chamber just inside the nozzle cap. The water enters from the back through a spring-controlled valve, the most recent design being shown in Fig. 11. The valve is designed so that it will not operate unless the pressure has reached a predetermined value. This is not attained at the nozzle until some time after the air has commenced to issue from the jet, so that all fear of dripping is avoided. Formerly the water-control valve was located close to the water filter. The air atomises the water as the two combine at the nozzle. The cap of the combination nozzle is arranged as a wing nut and is capable of adjustment. In addition, two wing-headed screws give adjustment of the water and air between the filters and the nozzle, while other two screw needle valves control the admission of air and water from the pipe lines. The bottoms of the filters are easily removable for cleaning purposes. The nozzle swivels so that the angle of direction of the jet can be adjusted in the vertical plane.

We have described the fountain humidifier at this stage because we considered it would be best to follow the air through from the compressor to its use at the jet. As already stated, after leaving the receiver the air line is branched, one supply going to the jets and the second to the water regulators. The regulating apparatus is shown in Figs. 13 and 14. These illustrate a small pattern suitable for fountains delivering up to 30 lb. of water per hour. A larger pattern is also made, but the principles embodied are similar, and therefore a description of one model will suffice. Air from the receiver is led into the water controller at the top through an adjustable reducing valve, in front of which may be fitted a filter if necessary. Water, in this pattern, is admitted through a cock, controlled by a float, at the bottom of the body of the machine. The pressure of the water supply must be at least 40 lb. at the highest controller in the building served by the installation, and if this is not otherwise available a pump is necessary to obtain this head. The float valve maintains a constant supply of water in the machine, while the air pressure forces the water out into the pipe line running to the fountain. A water filter may be fitted either on the supply or delivery side of the machine as shown, or on both if required. A non-return valve is fitted on the delivery side, and the machine is also supplied with a gauge column and a pressure gauge. Arrangements are also made for the supply of disinfectant to the water while in the machine. The reducing valve is adjustable, as stated, and a relief valve is fitted below the pressure gauge so that the air pressure above the water may be adjusted to suit the supply required. If the water supply is not free from suspended matter it is as well to place a large water filter in front of the water controllers. This filter has a body and cover similar to those of the controller illustrated in Figs. 13 and 14, the interior being fitted with a large copper strainer and canvas bag filter, both readily removable.

The apparatus so far described has been developed for humidifying the atmosphere in textile mills. In this connection it may be stated that one of its advantages lies in the fact that the humidifying action may be adjusted to meet any local conditions inside the mills. A recent application of the compressing and cleaning portions of the plant has been concerned with the use of pneumatic tools in workshops. Often in these cases the air supply is drawn from contaminated surroundings, and a good deal of dirt may find its way through to the tools, whose small parts become rapidly worn. The elimination of oil and water from the supply is also advantageous, and Messrs. Smethurst arrange sets for this purpose comprising the compressor, oil separator, coolers and filter-receivers.

Another use to which part of the apparatus is put is in connection with rock drilling. In this arrangement a 3-gallon water container and a spraying nozzle are used, worked off the same supply of air as is provided for the rock drills, &c. The container with its filter is mounted on a small trolley which also carries a drum accommodating two lengths of pressure hose, one for air and one for water. The nozzle, which is similar in principle to the air fountain already described, but modified considerably to suit, as regards design, is clamped to a small independent tripod at a height capable of adjustment, so that the spray can be directed on to the actual point of the work. This effectively eliminates all dust from the drilling operations. The water container is not coupled to any source of supply, but is filled as required by removing the cover. The machine is independent therefore except for the air connection. When working at maximum capacity the container will suffice for 1 hour. The sprayer can also be used in greenhouses and granaries, and is of service in other connections.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scottish Steel Trade.—A healthier tone is now prevailing in the Scottish steel trade, and there is a greater disposition on the part of consumers to place orders. The latter are nevertheless not too plentiful just yet, but a fair amount of orders for plates and sections have been booked, and inquiries are good. Prices are firming up and have an advancing tendency. The following may be taken as to-day's quotations:—Boiler plates, 12*l.* per ton; ship plates, 9*l.* per ton; and sections, 8*l.* 15*s.* per ton, all delivered Glasgow stations.

Black Steel Sheets.—Prices Advanced.—In the Scottish black steel sheet trade there has been more business passing of late both on home and export account. The heavier gauges are in better demand and so also are galvanised sorts. For the first time over an extended period an advance in prices has to be recorded. At a meeting of the Scottish Black Sheet Makers' Association, held in Glasgow on Monday of this week, it was arranged to advance prices from 5*s.* to 20*s.* per ton. The following are now the current rates:—Under $\frac{1}{4}$ in. to $\frac{1}{16}$ in., 11*l.* per ton; under $\frac{1}{16}$ in. to $\frac{1}{8}$ in., 11*l.* 10*s.* per ton; under $\frac{1}{8}$ in. to 16 g., 12*l.* 5*s.* per ton; under 16 g. to 20 g., 13*l.* per ton; under 20 g. to 24 g., 13*l.* 15*s.* per ton; under 24 g. to 27 g., 14*l.* 15*s.* per ton. The last alteration in prices was in August of last year, when a reduction of 15*s.* to 20*s.* per ton took place.

Malleable Iron Trade.—The West of Scotland malleable iron trade continues to move along just a trifle slowly, and new business is not coming in too satisfactorily. An increase is certainly noticeable and bookings are expected to get better very shortly. Owing to the present high cost of manufacture it was decided at a meeting of the Scottish makers, held in Glasgow, yesterday, to increase prices by 10*s.* per ton, making the basis price for "crown" quality 11*l.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—The conditions in the pig-iron trade of Scotland have barely changed over the week, but foundry grades are perhaps a trifle more in request. Stocks are, of course, accumulating, but that is not looked upon very seriously at present as a gradual opening-out of business is expected shortly. Hematite is in fairly good demand and likely to continue so, and an increased output is very probable soon. Prices are again strong, and are quoted to-day as under:—Hematite, 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 3*s.* per ton, and No. 3, 4*l.* 18*s.* per ton, both on trucks at makers' yards.

Shipments of Scottish Pig-Iron.—The amount of Scottish pig-iron shipped at Glasgow Harbour for the week ending Saturday last, January 27, was 7,608 tons. Of that total no less than 7,448 tons went foreign and the balance of 160 tons was coastwise. For the corresponding week last year the figures were 154 tons foreign and 66 tons coastwise.

Wages in the Iron Trade Reduced.—The following intimation has been made by Mr. John M. Macleod, C.A., Glasgow, to Messrs. J. C. Bishop and Coyle, joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board:—"In terms of the remit I have examined the employers' books for November and December, 1922, and certify that the average net selling price was 10*l.* 16*s.* 5·67*d.*" This means a decrease in the wages of the workmen of 2½ per cent. on basis rates.

Scottish Shipbuilding.—Work in the Scottish shipbuilding yards commenced rather slowly this year, but conditions are better now and are improving gradually. The booking of new vessels during the past month was fairly satisfactory considering present times, and overall somewhere about a dozen contracts have been reported. The launches during that period were very few, totalling only six, and the tonnage did not amount to an average January output. The figures were:—The Clyde, 4 vessels, of 15,695 tons; the Dee, 1 vessel of 590 tons; and the Forth, 1 vessel of 100 tons—making 16,385 tons altogether.

Large New Plate Mill at Blochairn.—An interesting function took place on Monday of this week when the large new rolling mill recently erected at the Blochairn Steel Works of the Steel Company of Scotland was started by Mrs. F. J. Stephen, wife of the chairman of the company. This mill is capable of rolling 1,500 tons of plates per week, and the first plate rolled on Monday was 4 ft. in width and of ¼-in. gauge, and was for the shipyard at Linthouse of Messrs. Alexander Stephen and Sons, the works of the steel company's chairman. The new addition to the Blochairn works consists of an 8-ft. plate mill driven by a Galloway engine of about 6,000 h.p., having three cylinders, each 46 in. in diameter, and a stroke of 54 in., and working at a pressure of 120 lb. per square inch at 60 r.p.m. The live roller gear is driven by four 60-h.p. motors, the screw-down gear by two 38-h.p. motors, and the skid gear by one 25-h.p. motor. The new heating furnaces are 20 ft. in length and 50 ft. in width, and there are also two reheating furnaces, each 30 ft. by 8 ft., and fired by producer gas. In the same bay there are new 5-ton slab-charging machines; while the firm have also laid down four Babcock and Wilcox boilers capable of evaporating 8,000 lb. of water per hour and of supplying the steam required by the new mill. The engine for the mill was made at Manchester, but all the castings and the majority of the other parts were made at the Hallside Works, Newton, belonging to the company. The slab-changing machines were supplied and erected by Sir William Arrol and Co., of Glasgow.

NOTES FROM THE SOUTH-WEST.

Cardiff, Wednesday.

The Coal Trade.—North-country coal prices have sharply risen to higher levels than those quoted for South Wales coals, and the Germans are now circulating inquiries for the Welsh commodity. Already quotations have been invited for supplying 50,000 tons of large coal at Hamburg and 60,000 tons to 70,000 tons at Hamburg or Rotterdam. The Paris-Orleans Railway is also inviting c.i.f. offers at the North French and Bay ports for 80,000 tons of small and the Belgian State Railways want offers for 56,000 tons to 80,000 tons of small at Antwerp, Ghent or Zeebrugge. The Norwegian State Railways, too, are inviting f.o.b. prices for 35,000 tons of best Admiralty large coal. The Egyptian State Railways have placed orders for 35,000 tons of Monmouthshire and second Admiralty large coal at 39*s.* 6*d.* c.i.f. Alexandria, which leaves an f.o.b. price of 27*s.* 6*d.* for the coal. The Mauritius Government has also ordered 30,000 tons of best Admiralty large coal and the Norte Railway of Spain has contracted for 20,000 tons of second Admiralty large coal, while the Andalusian Railway of Spain want tenders for 30,000 tons of large and 15,000 tons of small with delivery over the remainder of the year. The completion of business is very difficult, as most of the collieries are already well sold and abundantly supplied with shipping. There is a temporary famine in respect to small coals, and for the best steams up to 21*s.* 6*d.* is quoted with ordinaries commanding 20*s.* and drys from 17*s.* to 18*s.* In the majority of cases colliery salesmen are refusing to sell small except in conjunction with large, and demand 29*s.* 6*d.* to 30*s.* for best Admiralty large, 28*s.* 6*d.* for seconds and 27*s.* 6*d.* to 29*s.* for the leading Monmouthshires. These figures can, however, be discounted through merchants who hold a fair quantity of coal, bought on contract account at the end of last year or the beginning of this year. Shipment delays are, however, seriously interfering with business and causing colliery owners much trouble. An instance of how the inadequacy of the shipment facilities is affecting collieries will be gathered from the fact that yesterday an important combine with 72,000 tons of shipping actually in dock were compelled to suspend working at four pits because sufficient shipping was not in loading berths to absorb the full output of the pits controlled by the combine, and supply all the pits with the necessary number of wagons to keep the pits winding regularly. At the same time there were no less than 48 vessels in dock waiting for loading berths, though 96 vessels were actually under the tips at Cardiff, Penarth, Barry and Newport. Exports of coal as cargo last week to foreign countries amounted to 601,200 tons, which was 50,000 tons more than in the previous week and at the rate of 30,000,000 tons per annum. Of last week's shipments 216,000 tons were destined for France, 71,000 tons for Italy, 59,400 tons for South America, 26,700 tons for Spain, 21,500 tons for Portugal, 56,500 tons for British coaling depots, 77,300 tons for the United States, and 72,700 tons for "other countries," the latter including 12,400 tons to India and 4,600 tons to Germany.

Iron and Steel.—Exports of tin plates last week totalled 5,690 tons, compared with 4,933 tons in the previous week, black plates 2,037 tons against 4,857 tons, galvanised sheets 2,726 tons against 4,015 tons and other iron and steel goods 3,673 tons against 1,239 tons. The

tin-plate works are well booked up with orders, and prices are steadily upheld on the basis of 21*s.* to 21*s.* 6*d.* per basis box.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Notwithstanding a falling away of inquiries since the rise of prices with the New Year a strong note of optimism is sounded in the utterances of most of the business men of South Yorkshire. Firms have again got into regular work, and although short time is the rule, there are many signs that the worst period is over and a brighter prospect in view. The remarks of Mr. Sydney Robinson, acting chairman of the Chamber of Commerce, may well be quoted as representing the opinion of leaders in the industrial world. "Things," he said "are much better than they were. At my own works (Jessops) we are extending operations, we are putting more men on, and the wages sheet is increasing every week." Then, again, nothing could be more welcome than the fact that Sheffield's big army of unemployed is slowly but surely growing less. This week there are 800 fewer men on the registers at the Employment Exchange than last week's total. The operations in connection with the construction of the new battleships is absorbing a good many hands who had been idle for months. In different parts of the country new blast furnaces are being built, and many others which had been out of commission are being reconstructed and re-started immediately they are completed.

The Ruhr Situation.—The occupation of the Ruhr Valley is having indirectly a marked effect in Sheffield. For long the difference in the exchange has operated much to the detriment of Sheffield manufacturers. The Indian and South American markets, prolific sources of profit to the steel metropolis, were languishing in alarming fashion, and there is little doubt that much of the Belgian competition in tram rails and other productions of a like character had its origin in Germany. With this source of supply stopped, and a practical certainty of default in German deliveries, business is again being diverted to this side of the Channel, and inquiries are flowing in more freely than for months past.

Increased Prices.—Business in pig-iron and billets is brisk, and the strength of the position is shown in a still further advance in prices. The demand from America, the Continent, and the home market is such that the furnaces now in operation cannot meet current requirements. Acid billets have this week been advanced 20*s.* per ton, following one of 10*s.* in December, and the quotations for basic billets are up 10*s.* per ton. Local quotations to-day are:—Siemens acid billets, 11*l.* per ton; hard basic billets, 9*l.* 5*s.*; medium hard basic billets, 9*l.*; dead soft basic billets, 7*l.* 15*s.* to 8*l.*; Derbyshire foundry pig-iron, 4*l.* 8*s.* 6*d.*; Lincolnshire basic pig-iron, 4*l.* 10*s.*; Crown bar iron, 11*l.* 10*s.* to 12*l.*; soft basic wire rods, 10*l.* to 10*l.* 10*s.*; bright steel bars, 15*l.*; steel hoops, 12*l.*; iron hoops, 14*l.* The scrap market continues lively and prices still on the up-grade.

South Yorkshire Coal Trade.—Much excitement exists in the South Yorkshire coal trade at the rumours of huge German contracts having been placed. At first the opinion was general that German buyers were not in a position to give guarantees for payment, but this difficulty appears to have been got over by bank assurances that German magnates, including Stinnes, have made deposits in this country which will cover all orders actually accepted. It is estimated that the Humber ports have received contracts for between 250,000 tons and 300,000 tons between now and early May. Orders received, it is admitted, represent well over half-a-million pounds sterling. The result has been a general hardening of prices, and South Yorkshire steam hards are showing an advance of from 1*s.* to 2*s.* 6*d.* per ton. It is generally believed that the next fortnight will see a sharp advance in the demand for and price of fuel. Collieries are improving output as fast as they can. The demand for coking slack is increasing as the improvement grows in the iron and engineering trades. Blast-furnace coke is also harder, making from 22*s.* to 23*s.* at ovens. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 24*s.* to 26*s.*; Derbyshire best house, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire large nuts, 19*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*s.*; Yorkshire hards, 21*s.* to 22*s.* 6*d.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 9*s.* to 11*s.*; nutty slacks, 7*s.* 9*d.* to 9*s.* 9*d.*; smalls, 3*s.* to 5*s.*

PRODUCER GAS FOR MOTOR VEHICLES.—With reference to our former notes and articles on this subject (see ENGINEERING, vol. cxi, pages 530 and 739), we are informed that the Parker producer gas plant is being regularly shipped from England to the Colonies and oversea countries. The fuel used in the Colonies is wood charcoal, and the average fuel consumption for a 3-ton lorry, total weight 5 tons, is stated to be a little over 1½ lb. per vehicle-mile, thus showing a great saving over petrol.

THE LONGUEUIL PLANT, CANADA.—In the issue for January 13 of the *Montreal Gazette* it is stated that following upon arrangements between Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, London, and Messrs. Charles Walmsley and Co., Limited, Bury, England, the Longueuil plant hitherto owned by Messrs. Armstrong, Whitworth of Canada, Limited, is being turned over to a new Canadian company, called Charles Walmsley and Co. (Canada), Limited. The reorganised plant will be opened up at once for the manufacture of pulp and paper machinery and general engineering work.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, February 2, at 7 p.m., at Storey's Gate, St. James' Park, S.W. 1. Informal Meeting. "The Use of Light Alloys in Place of Iron and Steel," by Mr. A. E. L. Chorlton, C.B.E. (Member of Council). Friday, February 9, at 8 p.m.; Adjourned Discussion on Engine Indicators.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, February 2, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Lecturette, "Ventilation and Lighting of Factories" (Slides), by Mr. P. J. Waldram.

THE INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE UPON-TYNE ASSOCIATION.—Monday, February 5, at 7.30 p.m., in the Lecture Theatre, Neville Hall, Newcastle-upon-Tyne. Paper by Mr. E. L. Everatt, Stud.Inst.C.E., on "The Design and Construction of Steel-Framed Workshops."

THE BRADFORD ENGINEERING SOCIETY.—Monday, February 5, at 7.30 p.m., in the Hall of the Bradford Technical College. Lecture on "Stainless Steel, and Its Engineering Applications," by Mr. Harry Brearley.

THE INSTITUTE OF TRANSPORT.—Monday, February 5, at 5.30 p.m., in the Lecture Theatre, Institution of Electrical Engineers, Savoy-place, Victoria Embankment, W.C. 2. Paper on "Wagon Stock on British Railways," by Mr. H. N. Gresley, C.B.E. (Member of Council).

THE ROYAL SOCIETY OF ARTS.—Monday, February 5, at 8 p.m.: Cantor Lecture, "The Vulcanisation of Rubber," by Mr. Henry P. Stevens, M.A., Ph.D., F.I.C. (Lecture I). Wednesday, February 7, at 8 p.m.: Ordinary Meeting, "Electrical Resistance Furnaces and their Uses," by Mr. Charles R. Darling, A.R.C.Sc.I., F.I.C., F.Inst.P. Sir Robert Abbott Hadfield, Bart., D.Sc., D.Met., F.R.S., M.Inst.C.E., will preside.

THE INSTITUTION OF RUBBER INDUSTRY.—Monday, February 5, at the Engineers' Club, Coventry-street, at 7.30 p.m., when Mr. W. A. Williams, F.I.C., will read a paper on "Technology in the Rubber Industry." Chairman, Mr. H. W. Franklin.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 6, at 6 p.m. Paper to be submitted for discussion: "Wind Pressures, and Stresses Caused by the Wind on Bridges," by Mr. Douglas Henry Remfry, Assoc.M.Inst.C.E. And ballot for new members. Students' visit, Saturday (morning), February 10, to Messrs. J. Lyons's new factory at Greenford.

THE INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Tuesday, February 6, at 7 p.m., in the Chamber of Commerce, New-street. Discussion on "The Casting of Non-Ferrous Metals and Alloys."

AIR CONFERENCE.—Tuesday, February 6, at 10.30 a.m., at the Guildhall, London. The proceedings will be opened by the Right Hon. The Lord Mayor of London, and the chair will be taken by the Secretary of State for Air, Lieutenant-Colonel the Right Hon. Sir Samuel Hoare, Bart. Papers to be read: "The Position of Air Transport To-day," by Major-General Sir W. Sefton Brancker; "The Establishment of a Self-Supporting Airship Service," by Commander C. Dennis Burney. At 2.45 p.m. the chair will be taken by Sir Henry P. Maybury. Papers on "The Progress of Research and Experiment," by Air Vice-Marshal Sir W. G. H. Salmond, "Gliders and their Value to Aeronautical Progress," by Colonel A. Ogilvie; "Seaplanes," by Mr. C. R. Fairey. Wednesday, February 7, at 10.30 a.m. The chair will be taken by His Grace the Duke of Sutherland, and a general discussion on the papers read on the first morning will take place. At 2.45 p.m., the papers read on the first afternoon will be discussed, the chair being taken by Sir W. Joynson-Hicks, Bart.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Tuesday, February 6, at 2,30 p.m., the Annual General Meeting will be held at the Holborn Restaurant (Queen's Salon), London, W.C. 2. After the preliminary business has been disposed of a paper will be read by Professor W. E. Garner, M.Sc. (Chemical Engineering Department, University College, London), entitled "Theory of Combustion of Gaseous and Liquid Fuels," followed by discussion.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, February 7, at 7.30 p.m., at the Royal Institution, Colquitt-street, Liverpool. Paper on "Electric Propulsion of Ships," by Mr. R. S. Johnson.

THE INSTITUTION OF ELECTRICAL ENGINEERS: WIRELESS SECTION MEETING.—Wednesday, February 7 in the Lecture Theatre of the Institution, at 6 p.m. "The Measurement of the Electric Intensity of Received Radio Signals," by Mr. J. Hollingsworth (Associate Member).

THE INSTITUTION OF SANITARY ENGINEERS.—Wednesday, February 7, at 8 p.m., at Caxton Hall, Westminster, S.W. 1. "National Water Resources and Their Allocation," by Mr. Percy Griffith, M.Inst.C.E., F.G.S.

THE NEWCOMEN SOCIETY.—Wednesday, February 7, at 5.30 p.m., at the Alpine Club, 23, Savile-row, W.1 (nearest tube station Dover-street), when a paper will be presented by Mr. G. P. Baker, on "East Indian Cotton Prints and Paintings of the Seventeenth and Eighteenth Centuries."

THE INSTITUTE OF METALS: LONDON LOCAL SECTION.—Thursday, February 8, at 8 p.m., in the Rooms of the Institute of Marine Engineers, 85 to 88, The Minories, Tower-hill, E.1. Paper on "The Investigation of the Constitution of Alloys," by Miss M. L. V. Gayler, M.Sc.

THE WEST BROMWICH ENGINEERING SOCIETY.—Friday, February 9, at 7.30 p.m., at the Technical School, West Bromwich, a paper on "Wireless Telephony" will be read by Mr. Howard Littley. Lantern slides and experimental demonstrations.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, February 9, at 7.30 p.m., at 39, Victoria-street. Hon. Members' Lecture, "The Effect of Temperature on the Properties of Engineering Materials," by Professor F. C. Lea, D.Sc.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, February 9, at 7.30 p.m., in the Mappin Hall of the University, St. George's-square. Special Conjoint Meeting with the Faraday Society. Symposium on "Stainless and Non-Corrodible Alloys."

THE OPTICAL SOCIETY.—Thursday, February 8, at 7.30 p.m., at the Imperial College, Imperial Institute-road, South Kensington. Annual General Meeting for the presentation of reports and election of office bearers. Immediately after the Annual General Meeting an Ordinary Meeting of the Society will be held when the retiring president, Sir Frank Dyson, M.A., D.Sc., LL.D., F.R.S., Astronomer Royal, will deliver the Presidential Address; subject, "Large Telescopes." The paper by Mr. F. W. Preston, B.Sc. (Messrs. Taylor, Taylor and Hobson, Limited), "On the Properties of Pitch used in Working Optical Glass," which was presented at the meeting on January 11, will then be discussed. A new Prismatic Astrolabe designed at the Admiralty Research Laboratory will be exhibited and described by Commander T. Y. Baker, R.N., B.A.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 9, at 9 p.m., a discourse will be delivered by Sir John Russell, O.B.E., D.Sc., F.R.S. The subject is "Rothamsted and Agricultural Science." Afternoon Lectures, at 3 p.m.: Tuesday, February 6, Mr. R. D. Oldham, F.R.S., on "The Character and Cause of Earthquakes" (Lecture II); Thursday, February 8, Mr. I. M. Heilbron, D.S.O., D.Sc., Ph.D., F.I.C., on "The Photosynthesis of Plant Products" (Lecture II); Saturday, February 10, Mr. J. C. Squire, M.A., "Subject in Poetry" (Lecture II).

THE SOCIETY OF CHEMICAL INDUSTRY: CHEMICAL ENGINEERING GROUP.—Friday, February 9, at 8 p.m., at the Chemical Industry Club, 2, Whitehall-court, S.W.1. Paper by Professor F. G. Donnan, F.R.S., on "Some Control Formulæ in connection with Leaching and Evaporating."

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Values of Cleveland pig-iron are advancing, but the qualities of iron in most demand are so scarce as to be practically unobtainable. No. 1 is nominal at 110*s.* There is now no No. 3 available for sale, but the most recent transactions were in small lots at 105*s.*, and such sales have established the figure named as the recognised market quotation. Makers are unable to entertain offers for No. 3 for delivery before March. Siliceous iron is no longer extremely scarce, with the result that after having for some time past commanded the same price as No. 1 it is now offered at the figure ruling for No. 3. Foundry 4 is fully 95*s.*, and has become quite scarce as the result of extensive buying of that quality by customers who usually take No. 3 and who cannot obtain adequate supplies of the latter. There is not much No. 4 forge on sale and the price is 90*s.* The foregoing quotations are once more admitting of successful competition in certain markets by sellers of Midland and Continental irons.

Hematite.—A rise in hematite is no more than was expected. It is indeed long overdue, and leaves values still low in comparison with rates ruling for Cleveland pig-iron. A very extensive business has been put through in East Coast hematite, and whilst there is no real shortage, supplies are now by no means plentiful. Mixed Nos. are very firm at 100*s.*

Foreign Ore.—Sales of imported ore are not extensive, consumers still being disinclined to commit themselves at all heavily, but sellers report rather more inquiry, and speak quite hopefully of the future. Best rubio is round about 24*s.* c.i.f. Tees, and good Mediterranean ores are put at 22*s.* 6*d.* c.i.f. Tees.

Coke.—Durham blast-furnace coke is very strong. Though local users endeavour to purchase at less, the general market quotation for average descriptions is 32*s.* 6*d.* delivered, and is likely to advance.

Manufactured Iron and Steel.—In nearly all departments of finished iron and steel, manufacturers have quite good order books, and they report inquiries as numerous as ever. Thus the general situation may be described as satisfactory, and prospects as brighter and more encouraging than for a long time past. Recent heavy sales have been chiefly in rails on both home and export account, and in shipbuilding material. Prices, all round, are very firm. The following are among the principal market quotations:—Common iron bars, 11*l.*; iron rivets, 11*l.* 7*s.* 6*d.*; steel billets, 8*l.* 10*s.* to 9*l.* 5*s.*; steel boiler plates, 13*l.*; steel ship, bridge and tank plates, 9*l.* 5*s.* to 9*l.* 10*s.*; steel angles, 8*l.* 15*s.* to 9*l.*; steel joists, 9*l.*; heavy steel rails, 9*l.*; fish plates, 13*l.*; and galvanised corrugated sheets, 18*l.* 10*s.*

PERSONAL.—The offices of the Nederlandsche Dok-Maatschappy, Amsterdam, have been transferred from Keizersgracht 637, to the wharf Noorder Ypolder.

COMPRESSING AND AIR HUMIDIFYING PLANT.

CONSTRUCTED BY MESSRS. HERBERT SMETHURST AND SONS, LIMITED, ENGINEERS, HOLLINWOOD, LANCS.

(For Description, see Page 141.)

Fig. 1.

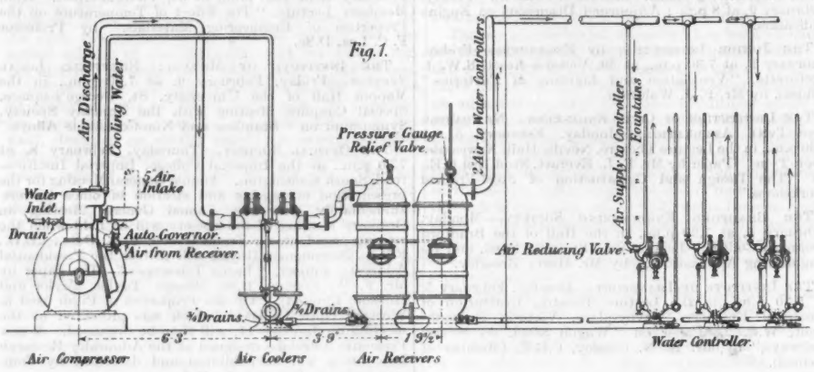


Fig. 2.

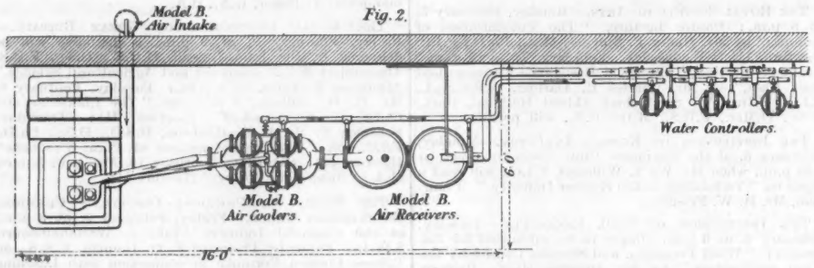


Fig. 3.

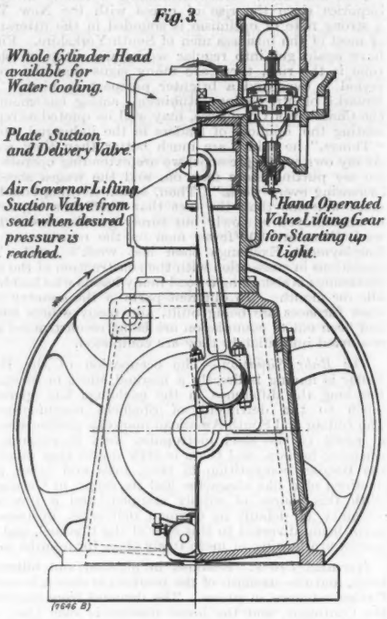

Whole Cylinder Head available for Water Cooling.
Plate Suction and Delivery Valve.
Air Governor Lifting Suction Valve from seat when desired pressure is reached.
Hand Operated Valve Lifting Gear for Starting up Light.

Fig. 4.

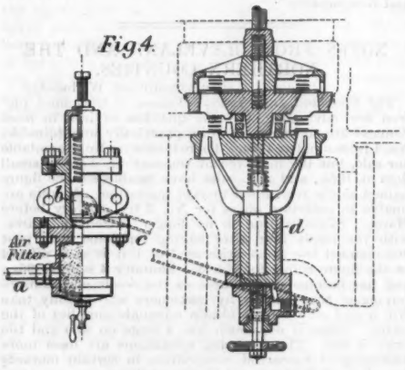


Fig. 5.

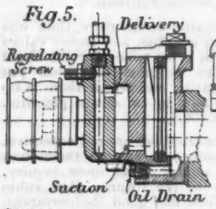


Fig. 6.

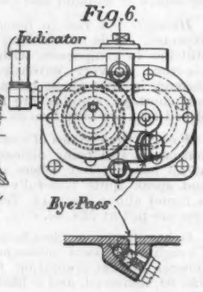


Fig. 7.

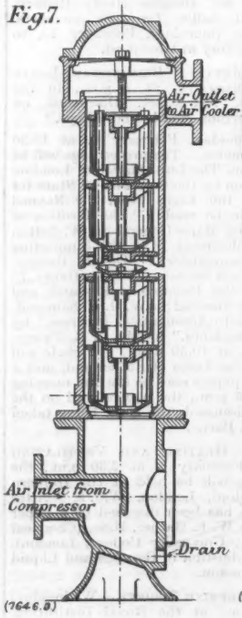


Fig. 8.

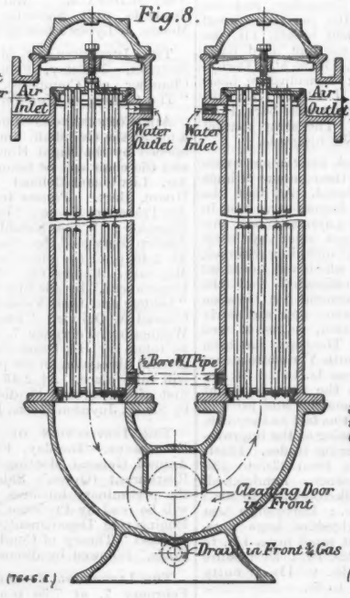


Fig. 9.

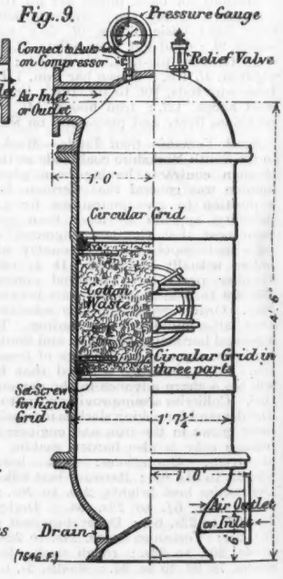


Fig. 10.

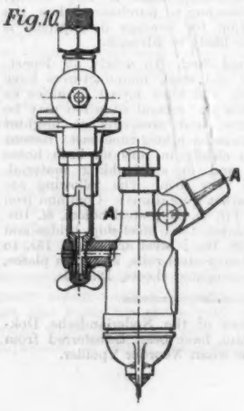


Fig. 11. SECTION A.A.

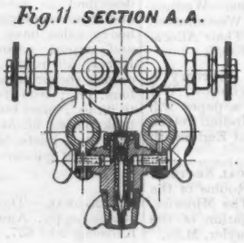


Fig. 12.

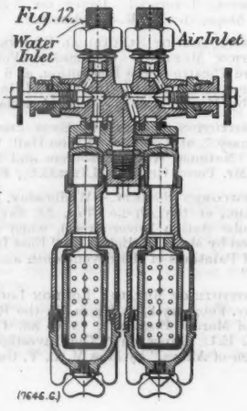


Fig. 13.

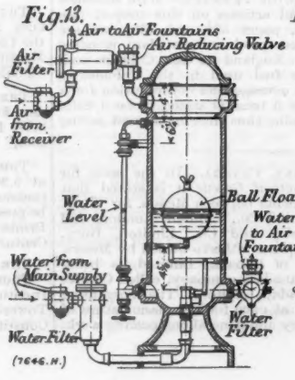
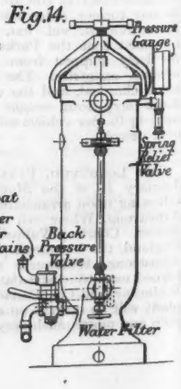


Fig. 14.



18-IN. TELESCOPE AT THE NATIONAL OBSERVATORY, RIO DE JANEIRO.

CONSTRUCTED BY MESSRS. T. COOKE AND SONS, LIMITED, YORK.

FIG. 3. VIEW OF TELESCOPE AS SEEN THROUGH OPENING IN THE OBSERVATORY DOME.

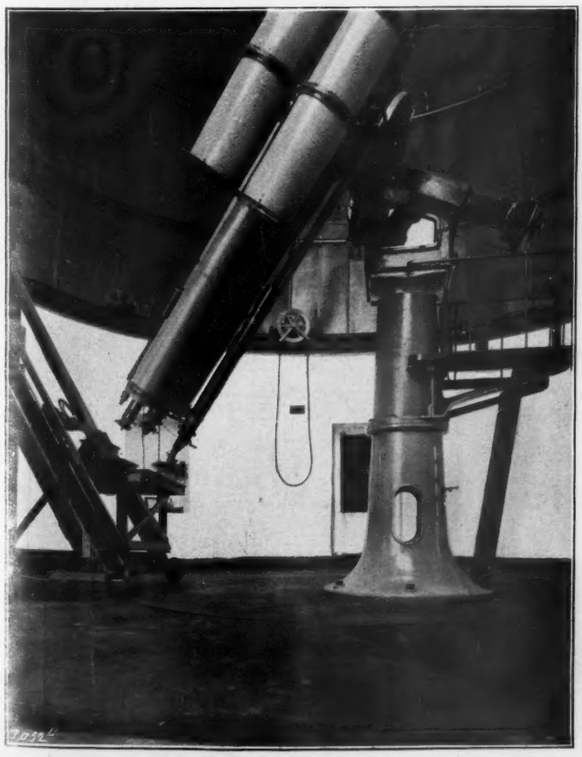


FIG. 4. VIEW OF LOWER PART OF MOUNTING.

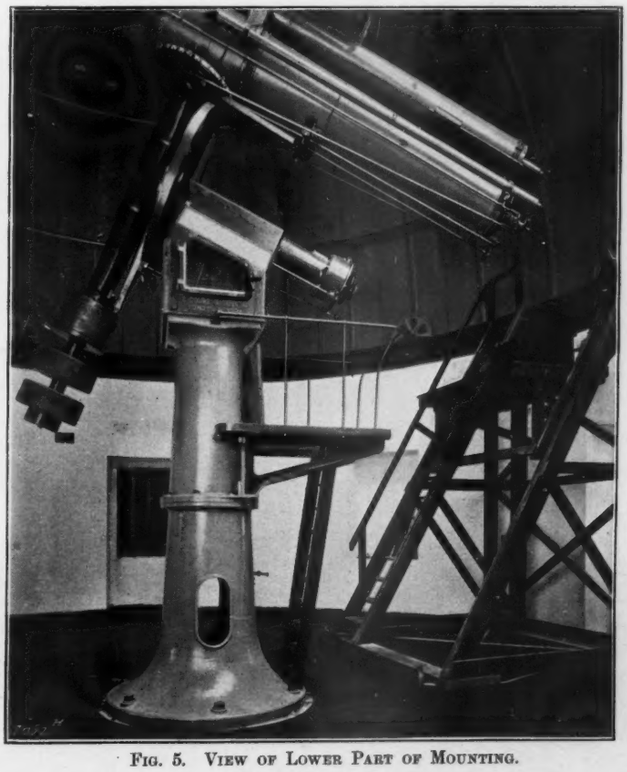


FIG. 5. VIEW OF LOWER PART OF MOUNTING.

(*To face Page* 130.)

18-IN. TELESCOPE AT THE NATIONAL OBSERVATORY, RIO DE JANEIRO.

CONSTRUCTED BY MESSRS. T. COOKE AND SONS, LIMITED, YORK.

(*For Description, see Page* 130.)

Fig. 6.

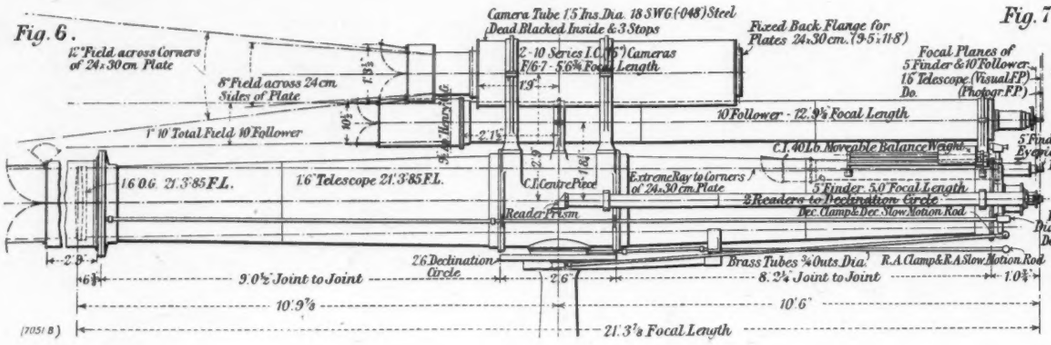

Camera Tube 15 Ins. Dia. 18 SWG (·048) Steel
Dead Blacked Inside & 3 Stops
Fixed Back Flange for Plates 24×30 cm. (9·5 × 11·8)
12° Field across Corners of 24×30 cm. Plate
8° Field across 24 cm. Sides of Plate
2-10 Series I. (C.16) Cameras F/6·7 · 5·6% Focal Length
19"
10 Follower · 12·9⅛ Focal Length
1° 10 Total Field 10 Follower
2·15"
C.I. 40 Lb. Moveable Balance Weight
16 0 G 21·3·85 F.L.
1·6 Telescope 21·3·85 F.L.
C.I. Centre Piece
Extreme Ray to Corners of 24×30 cm. Plate
5 Finder · 5·0 Focal Length
2 Readers to Declination Circle
Reader Prism
Dec. Clamp & Dec. Slow Motion Rod
2·6 Declination Circle
Brass Tubes ¾ Outs. Dia.
R.A. Clamp & R.A. Slow Motion Rod
9·0½" Joint to Joint
8·2¼" Joint to Joint
10·9⅞"
10·6"
21·3⅞" Focal Length
Focal Planes of 5 Finder & 10 Follower.
15 Telescope (Visual F.P.)
Do. (Photogr. F.P.)

Fig. 7.

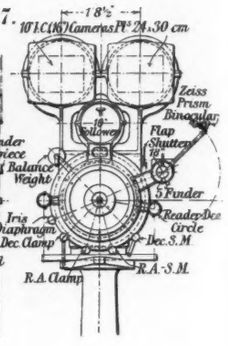


Fig. 8.

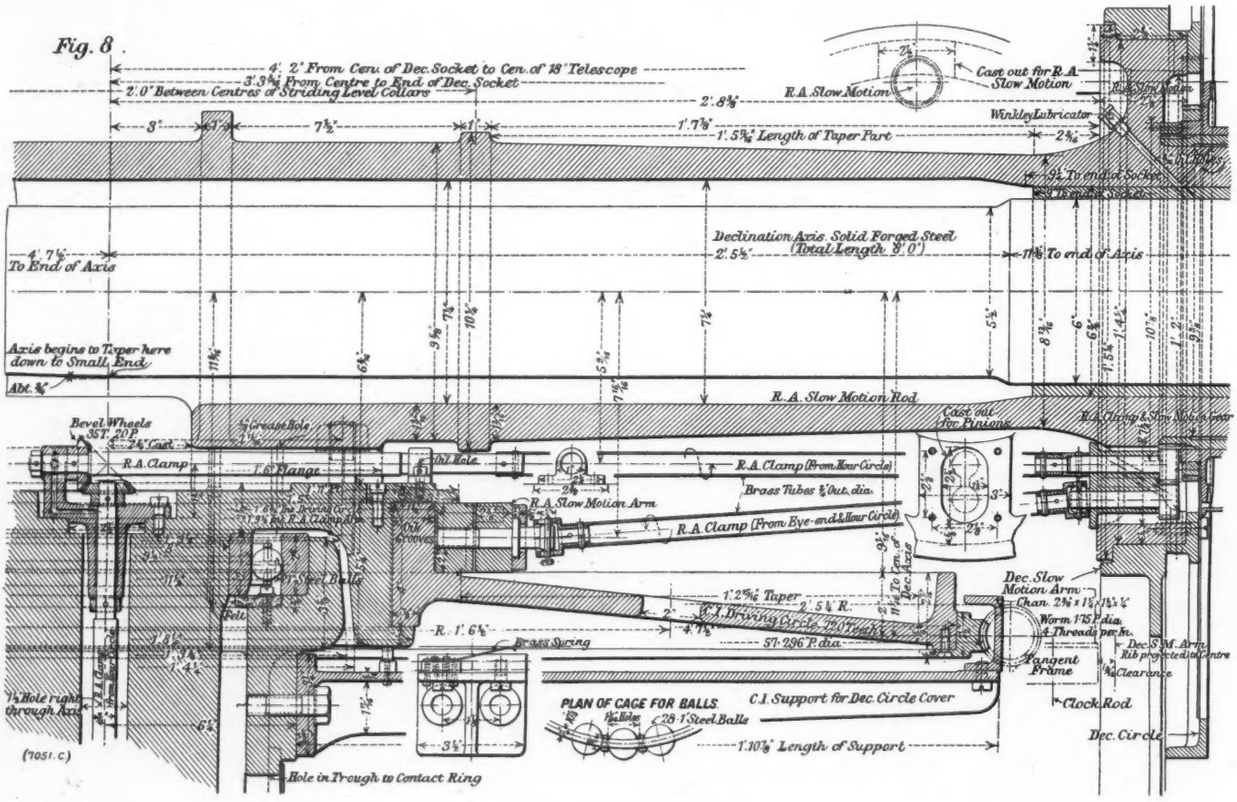

4'. 2" From Cen. of Dec. Socket to Cen. of 18" Telescope
3'.3⅜" From Centre to End of Dec. Socket
2'.0" Between Centres of Striding Level Collars
Cast out for R.A. Slow Motion
R.A. Slow Motion
Windley Lubricator
1'.5⅜" Length of Taper Part
Declination Axis Solid Forged Steel (Total Length 8'.0")
To End of Axis
Axis begins to Taper here down to Small End
R.A. Slow Motion Rod
Cast out for Pinions
Bevel Wheels 85T. 20 P.
R.A. Clamp
R.A. Clamp (From Hour Circle)
Brass Tubes ⅞ Out. dia.
R.A. Slow Motion Arm
R.A. Clamp (From Eye- and Hour Circle)
1'.2⅝ Taper
C.I. Driving Circle 720 Teeth
Brass Spring
57·296 P. dia.
Dec. Slow Motion Arm
Worm 1·75 P. dia.
4 Threads per In.
Tangent Frame
Clock Rod
Dec. Circle
PLAN OF CAGE FOR BALLS
28 1" Steel Balls
C.I. Support for Dec. Circle Cover
1'.10⅞" Length of Support
Hole in Trough to Contact Ring

Fig. 9.

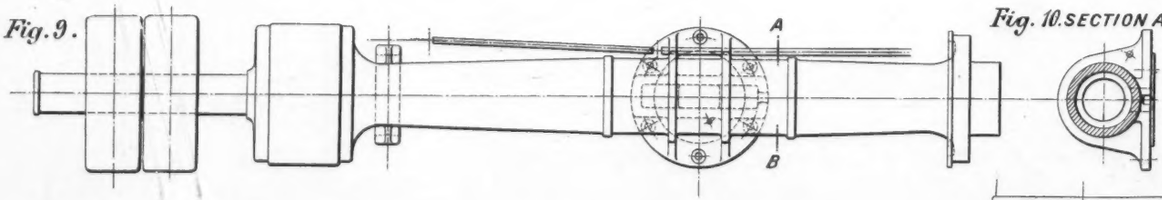
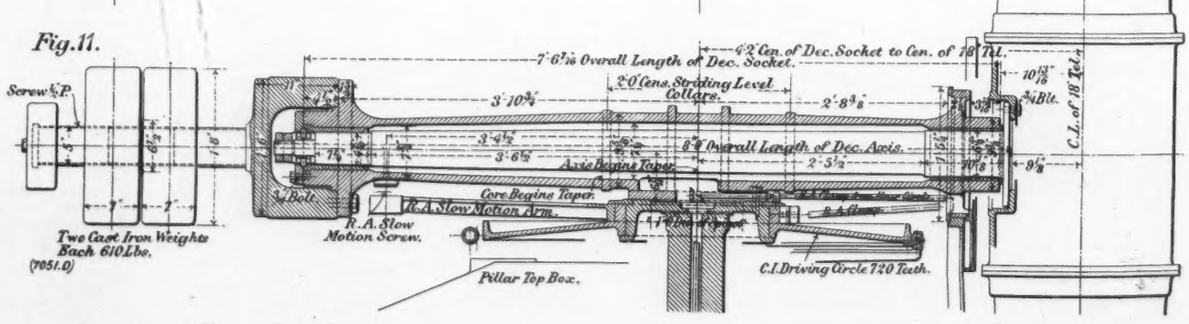


Fig. 10. SECTION A.B.

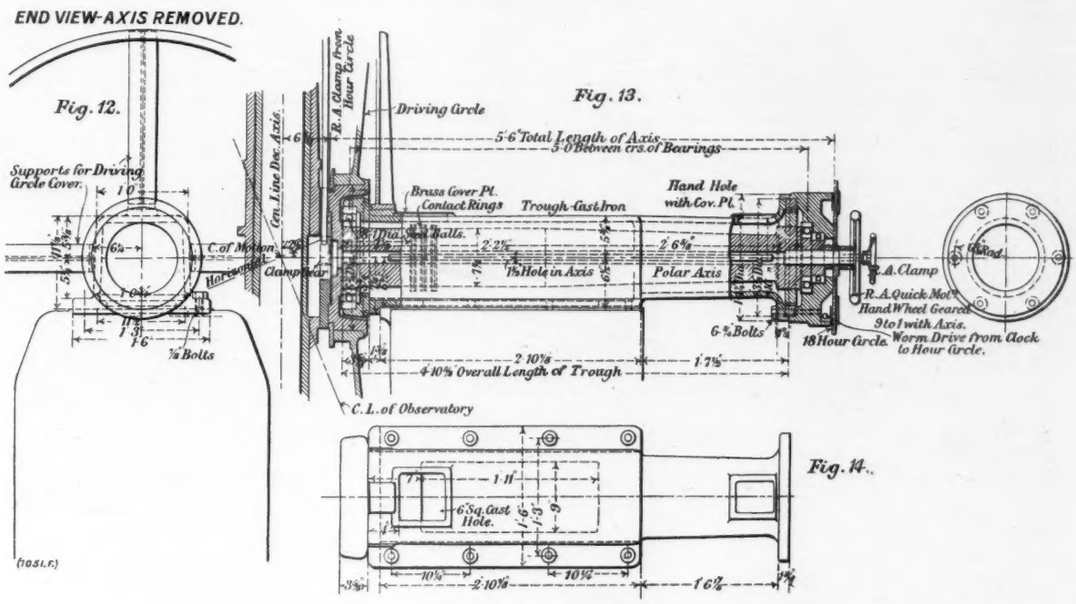
Fig. 11.


7'.6⅞" Overall Length of Dec. Socket.
4'.2" Cen. of Dec. Socket to Cen. of 18" Tel.
2·0 Cens. Striding Level Collars.
8'.0" Overall Length of Dec. Axis.
Axis Begins Taper.
Core Begins Taper.
R.A. Slow Motion Arm.
R.A. Slow Motion Screw.
Two Cast Iron Weights Each 610 Lbs.
Pillar Top Box.
C.I. Driving Circle 720 Teeth.
C.I. of 18" Tel.

18-IN. TELESCOPE AT THE NATIONAL OBSERVATORY, RIO DE JANEIRO.

CONSTRUCTED BY MESSRS. T. COOKE AND SONS, LIMITED, YORK.

(*For Description, see Page* 130.)



FIGS. 12 TO 14. DETAILS OF POLAR AXIS.

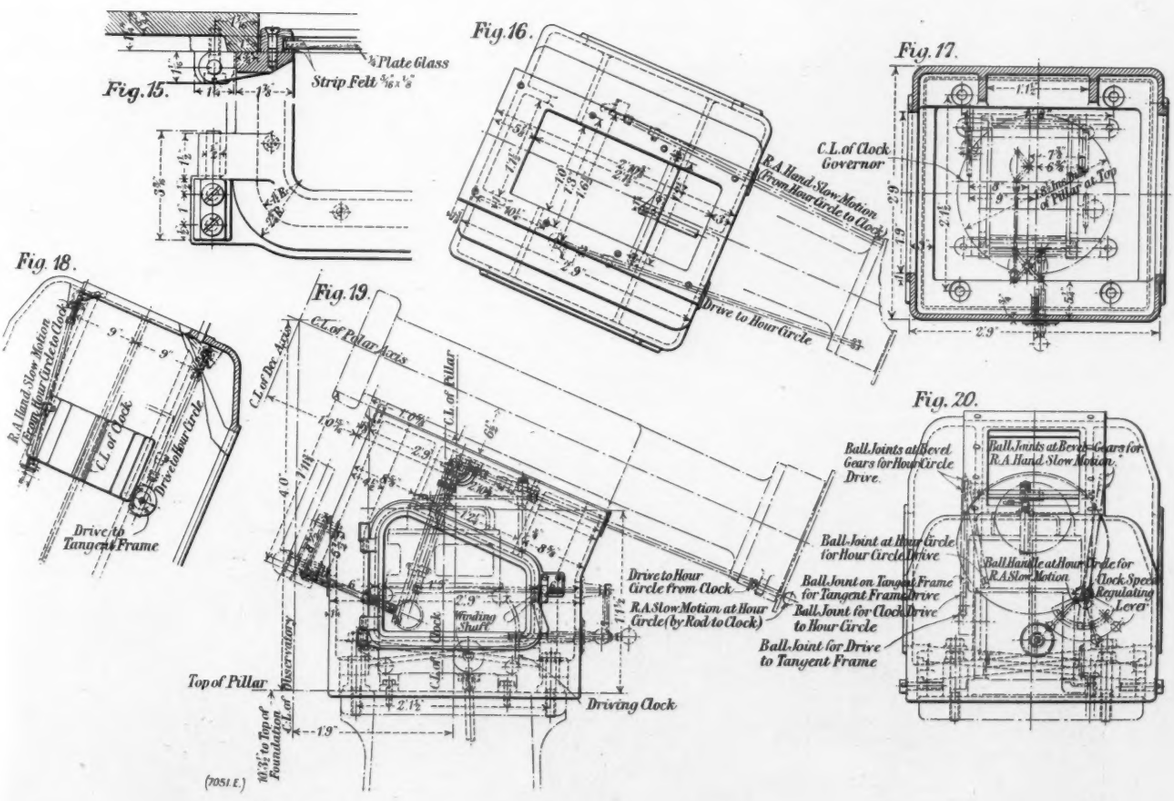


Fig. 15.
⅛ Plate Glass
Strip Felt
Fig. 16.
R.A. Hand Slow Motion from Hour Circle to Clock
Drive to Hour Circle
Fig. 17.
C.L. of Clock Governor
Fig. 18.
R.A. Hand Slow Motion from Hour Circle to Clock
C.L. of Clock
Drive to Hour Circle
Drive to Tangent Frame
Fig. 19.
C.L. of Polar Axis
C.L. of Dec. Axis
C.L. of Pillar
Drive to Hour Circle from Clock
R.A. Slow Motion at Hour Circle (by Rod to Clock)
Winding Shaft
Top of Pillar
Driving Clock
C.L. of Observatory
Fig. 20.
Ball Joints at Level Gears for Hour Circle Drive.
Ball Joints at Bevel Gears for R.A. Hand Slow Motion.
Ball-Joint at Hour Circle for Hour Circle Drive
Ball Joint on Tangent Frame for Tangent Frame Drive
Ball Joint for Clock Drive to Hour Circle
Ball-Joint for Drive to Tangent Frame
Ball Handle at Hour Circle for R.A. Slow Motion
Clock Speed Regulating Lever

FIGS. 15 TO 20. DETAILS OF MOUNTING AND CLOCK CASE AT TOP OF MAIN COLUMN.

SPERRY GYROSCOPIC SHIP STABILISER FOR JAPANESE CRUISER.

(*For Description, see Page* 140.)

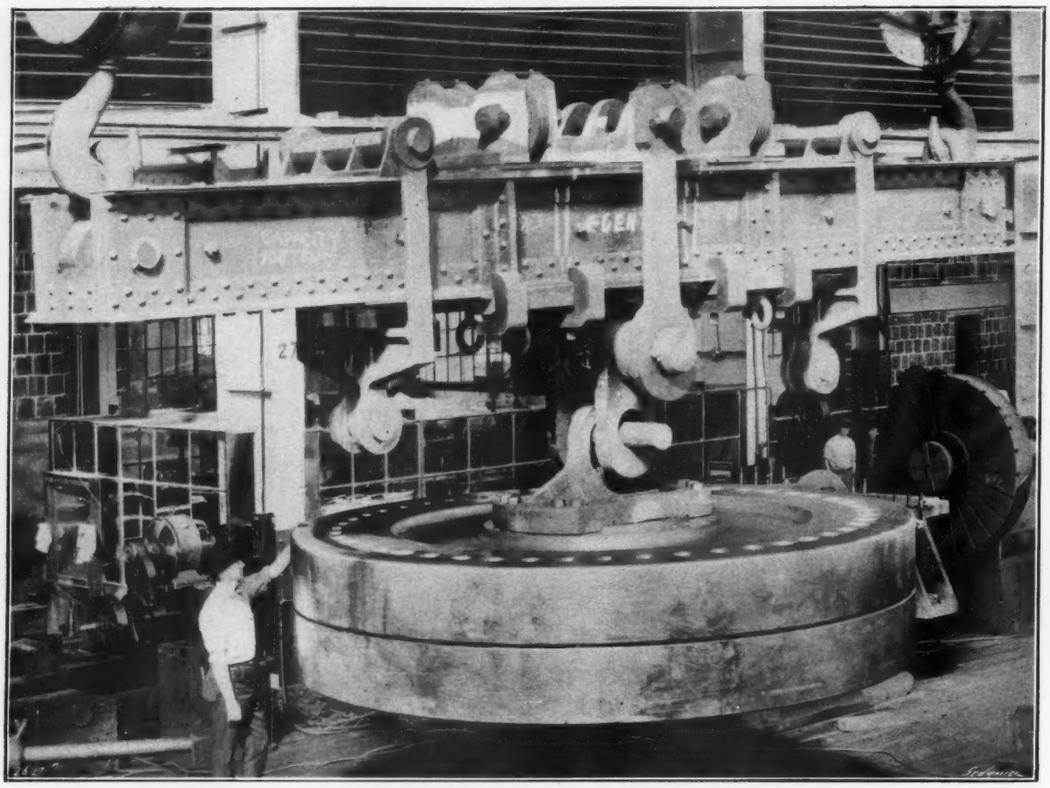


FIG. 1. VIEW OF ROTOR BEFORE FITTING WITH SHAFT STUBS AND BALANCING PLUGS.

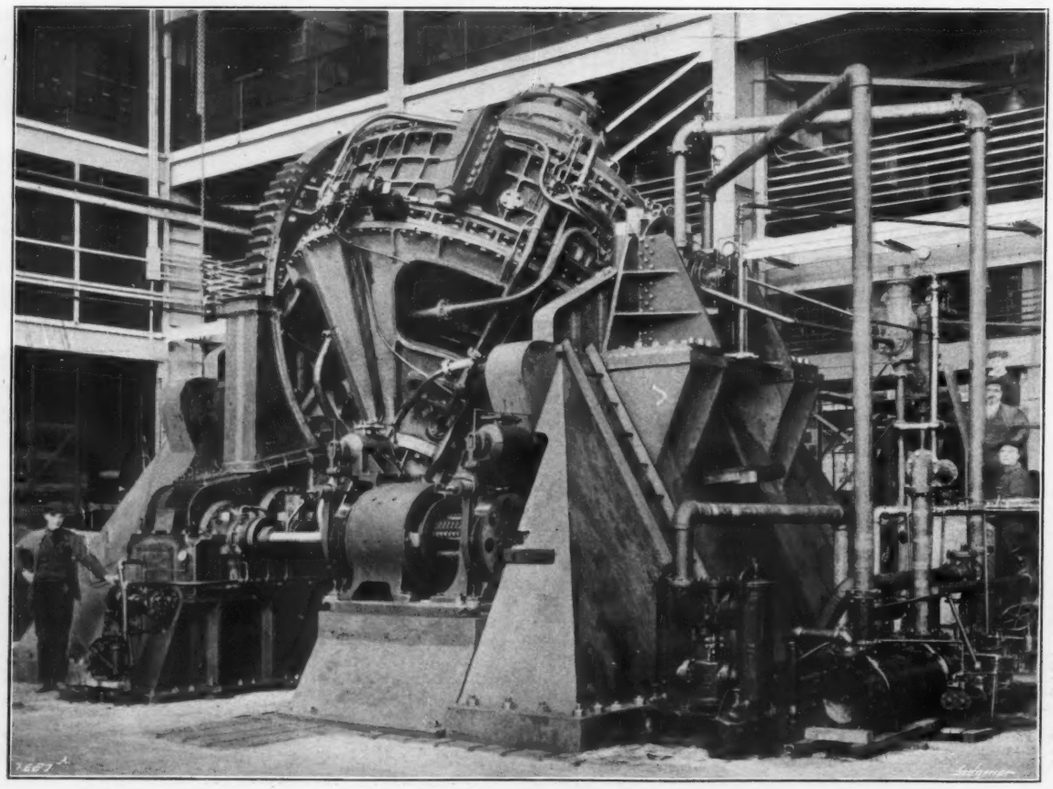


FIG. 2. THE ASSEMBLED EQUIPMENT UNDER TEST IN THE WORKS.

(*To face Page* 131.)

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Three One-Page Plates.—18-*IN. TELESCOPE AT THE NATIONAL OBSERVATORY, RIO DE JANEIRO.*

One One-Page Plate.—SPERRY GYROSCOPE SHIP STABILISER FOR JAPANESE CRUISER.

ENGINEERING.

FRIDAY, FEBRUARY 2, 1923.

THE INTERNAL COMBUSTION LOCOMOTIVE.

IT is many years since the development of the internal-combustion engine had advanced sufficiently far for it to appear an attractive form of power for railway purposes. In the meantime a great deal of progress has been made with this type of motor in marine engineering, but no similar advance has occurred in the locomotive world. The thermal economy of the oil engine, the elimination of boiler troubles, and the suppression of standby losses are all good arguments in favour of such an engine, yet none has so far been produced capable of meeting the requirements of services of any but a very limited character. Small engines were successfully used during the war on a comparatively large scale, and are often found in industrial surroundings, but that is as far as the subject has got, except for some experimental work and drawing board designs.

The fact is that the conditions of railway working are unfavourable to the internal-combustion engine, and in the process of adaptation it becomes overloaded with contrivances which severely handicap it. Some day these may be so improved that the machine as a whole may be acceptable despite the complications, but at present we are very far from that stage. For a modern main line operation it is necessary to think in units of about 1,000 h.p. If these could be built, self-contained, it would doubtless tend to defer the consideration of electrification with its heavy transmission costs. For units of this size the internal combustion engine presents very great difficulties. These have been reviewed in a paper read by Mr. J. S. Tritton before the Institution of Locomotive Engineers, on the 25th ult.; they were also considered, but in connection with rather smaller units, in a paper by Mr. W. Burn read last year before the North-East Coast Institution of Engineers and Shipbuilders. The latter paper laid stress upon one of the chief difficulties of the application, namely, the extraordinary degree of flexibility required in locomotive operation, while the former paid rather more attention to a second and no less important problem, namely, transmission.

We may say at once that Mr. Burn's proposal of an opposed piston type of engine operating at starting on air supplied by an independent compressing set, strikes one as a very cumbersome arrangement which would be clearly inefficient for many classes of service. The duplication of plant is a great handicap to the Diesel locomotive. Even if a good method of direct driving were feasible for the main engine, the compressor plant must have a capacity sufficient to take full load at starting under maximum torque conditions. Either with or without storage, the air plant would be bulky and heavy, and the operations of changing over inconvenient when the engine crew needed their attention for other duties.

For the ordinary type of Diesel engine, as Mr. Tritton has pointed out, the usual arrangement of multi-cylinders in line or arranged on the vee principle, involves for large powers a longitudinal disposition of the unit, with, consequently, a right-angled drive. The difficulties of satisfactorily effecting this, and working in all the necessary accompaniments of clutch and reversing, have diverted attention to the less direct methods of driving through electrical or hydraulic transmission. These also involve complications, though of another type; neither has so far been brought to the practical stage in large units. At least one firm after the attempt abandoned hydraulic transmission as inefficient, while the powers which would be required are rather in excess of those for which this system has as yet been applied with practical success.

In other systems the additional weight is one of the main drawbacks. It would seem to stand to reason that if an excellent electric locomotive can be designed to come nicely within the permanent-way weight restrictions, a Diesel-electric of the same weight disposition must be of considerably less power since the traction machinery is virtually triplicated. There must be first the full-powered engine unit, next a corresponding generator, and finally the traction motors. So far as the permanent-way questions are concerned, the greater power would be secured for equal weight by the simple electric locomotive. The costliness of such duplication is also very great and the electric equipment relatively expensive. The remark also applies to any internal-combustion multi-cylinder unit of large size at all applicable to locomotive work. While the steam locomotive of to-day is much more expensive to construct than formerly was the case, the multi-cylinder Diesel with its supplementary air plant, and/or with electric generation and driving, would so much exceed the steam locomotive in first cost that any advantage arising from improved economy in operation would be largely, if not completely, extinguished. It may reasonably be accepted that the electrical equipment could be made to serve satisfactorily. It is quite another matter with regard to the performance of an high-speed multi-cylinder Diesel engine. This type of machine has never yet been tried under the severe conditions of locomotive operation, and would almost certainly involve heavy maintenance. Here, again, the longer periods between stoppings which are possible with the electric locomotive as compared with the steam machine, would be reduced to the time it would be possible to keep the Diesel engine out of the works. With present designs it would be no wonder to find that the Diesel electric machine had no advantage over the steam engine in this respect. This is pure conjecture, for there has been no railway experience with multi-cylinders, cams and tappets.

Thus there are many difficulties in the way of realisation of the idea of an internal-combustion locomotive. And supposing we got a satisfactory design as regards cheapness, power and disposition of weight, could we also get the essential of

flexibility or sensitiveness so admirably met by the steam locomotive, and the electric machine? In both these the starting and stopping of a 1,000-h.p. unit is a simple matter, while control and regulation are practical in character. It is another matter with the internal combustion engine. It is true that reversing has been worked out for motor-driven vessels, but no system yet designed would serve on a locomotive. We are, as a matter of fact, much where we were years ago on this subject, and all attempts to produce the internal-combustion locomotive have resulted in no more than a few machines of small power, or the abandonment of experiments. Mr. Tritton's paper we take it was more a summary of the situation than a contribution towards the solution of the problem. When the Transcontinental line was undertaken in Australia many people were optimistic enough to assert that by the time it was opened for traffic, main line engines of the type would be available for use over the waterless districts. From the small advance in the interim it seems unlikely that we shall see anything of the kind for a very considerable time. The two attractions are economy and the ability to start up without much preparation, but we fear these commendable features will not be practically embodied in an internal-combustion locomotive based on any form of this type of motor as we now know it.

LATHE TOOLS.

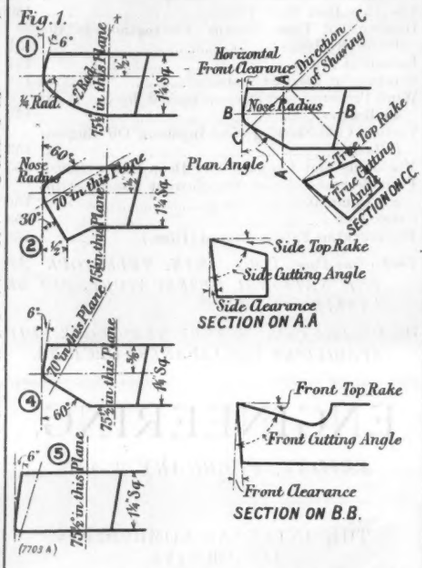
The question of the form of lathe tools is of perennial interest. No other class of tools is used so extensively, for the types are employed not only in lathes of all descriptions, but also in reciprocating machines. The various aspects of the subject have been studied by the aid of thousands of experiments. Hitherto, the common round nose has usually been taken as the type, and the changes have been rung on cutting angles, on top rake, and front clearance. Extreme forms have been included that would stand condemned at once by a competent turner. It may be stated that, generally, the results of experiments have tended to confirm the best practice of the shops which has been arrived at after long use and observation.

But there is another aspect which has received little attention outside the shops—that which relates to the plan angles of lathe tools other than the regular round nose forms. These may be regarded as modifications of the round nose. They have come into use largely in turret work, and in association with the use of high-speed tool steels for taking coarse cuts on tough forged steels. Years ago they were termed tools with "double edges," one, the forward edge producing the depth of cut, the following edge merely smoothing the surface. Such tools are either straightforward, that is, the cutting radius or edge is a continuation of the shank of the tool, or they are bent in the direction of cutting. Either may have a top rake, straightforward, or side top rake that lies in the angle of the bending, a shape which is now extensively used.

The greatest angle, in plan, between the cutting edge and the work is 90 deg., when the cutting edge is parallel with the shank. A clearance of 6 deg. with the side of the bar being turned is imparted to the end of the tool. All the cutting is done with the front or leading edge, as in the case of a "knife-tool." The cut is deep, the traverse fine, and a smooth surface is left. This is the principal tool used for rapid reduction in turret lathe work. Modified from this form are the numerous tools brought into service in recent years, in which the plan angles on the leading or cutting edge range from about 30 deg. upwards, that is, measured between the sloping front face and the side of the bar being turned. The clearance at the rear is generally 6 deg., but it may be more. The radius of the nose at the meeting of the two angles varies. Another common form is the round nose, the leading edge of which is a curve of large radius, merging in a small one where the clearance angle meets it. All these are excellent roughing tools, and they have largely taken the place of the earlier simple round nose. On tools of this class an exhaustive report has been issued by the Lathe Tools Research Committee of the Manchester Association of Engineers. The investigation was carried out under the supervision of Mr. Dempster Smith, and the results are published in a pamphlet by His Majesty's Stationery Office. Beyond the variations in plan angles, few differences were made. In most cases the cutting angle was 70 deg., measured as side top rake or that which is normal to the leading edge, or in the approximate plane of the shaving, giving a top rake of 14 deg. and a clearance of 6 deg. This corresponds with the angle that is most commonly adopted for cutting steel. This definition of side top rake will be understood from the cross-sections illustrated below. The tool plans given at (1), (2), (3) and (4), indicate the tool forms tested.

The cutting speeds were selected with a view to economise time and material and cause the edge of the tool to break down in about 20 minutes. As this period is too short for shop service, a series of curves has been plotted from which the high speed can be modified to harmonise with a run of greater length. Thus, if the speed appropriate for a 20 minutes' run on a given cut, and material is found to be 120 ft. per minute, the curves plotted indicate that, under the same conditions, the suitable speed for a 2 hours' run would be 96 ft., and for a 4 hours' run, 88 ft. per minute. These

Fig. 1.



results are plotted from an empirical constant $\frac{1}{V T^n}$, where n has an approximate value of 8. V is the cutting speed in feet per minute, T the life of the tool in minutes, the duration of the run. The product of the cutting speed, V and the $\frac{1}{8}$ power of the duration of the run is the constant used.

The experiments had for their object the determination of the durability of tools under various operating conditions, such as different cutting speeds, various ratios of depth of cut to traverse, different tool angles, and nose radii, with and without cooling medium, &c. The types of tools selected were a round nose, having the rather large radius of 2 in. on the leading edge, and a $\frac{1}{4}$ in. radius at the point, with 6 deg. of clearance on the following edge, and having side top rake. A tool with a plan angle of 30 deg. on the leading edge, and the very large clearance of 60 deg. at the rear. One of 60 deg. plan angle in front, and 6 deg. clearance, and the 90 deg. tool previously mentioned, with 6 deg. of clearance. This had a cutting angle in the plane of the shaving of 75 deg., the others an angle of 70 deg. The four tools are shown in Fig. 1.

The following, among other facts elucidated, are of interest to tool users. The permissible cutting speed increases very rapidly as the traverse diminishes below the point at which the ratio of the depth of cut to the traverse is unity. But it increases comparatively slowly for traverses greater than this. The 90-deg. tool commonly used on turret work, with deep cuts and fine traverses, did not show performances so good as those of the other tools, which is rather surprising. But the conditions were not precisely those usually met, since the report states that this tool was used on a bar of 12-in. diameter, while turret work is mostly done on bars below 3 in. or 4 in., where the cutting speed at the point of the wide tool is considerably less than that at the outer edge. The tool left a comparatively ragged surface on the bar, under all cuts; and on the deeper cuts, vibration took place in a direction parallel with the axis of the bar.

It was also observed that the relative performance of the 60-deg. tool (4) of Fig. 1 improves as the ratio of depth of cut to traverse becomes greater or less than unity, that it surpasses the round nose for traverses less than $\frac{1}{32}$ in., and closely approaches the performance of the 30-deg. tool ((2) of Fig. 1) with finer traverses. The last named chattered badly on all cuts, which became more pronounced as the thickness of the shaving diminished. The vibration occurred in a direction normal to the axis of the bar. The 60-deg. plan angle tool gave a uniformly smooth cutting action. The round nose caused vibration on the finer traverses. The deductions were, that should the work, or machine, be sufficiently stiff, or of a character to permit of a small plan angle tool, say, 30 deg. or 45 deg., being used, then the cutting speed may safely be taken as 1·55 or 1·21 times respectively that given for the 60-deg. plan angle tool. But should circumstances demand that a 75-deg. or a 90-deg. plan angle tool be used, then the permissible cutting speed is respectively 88 per cent., or 82 per cent. of that given for the 60-deg. plan angle tool.

The experimenters sought next to ascertain why the cutting performance of any one tool is a minimum when the ratio of depth of cut to traverse is unity, and improves for values greater or less than this. Also why the performance of one tool is better than that of another on any one cut, and why the relative superiority of one tool over another is not maintained at all cuts.

The first is explained thus. The intensity of pressure due to crowding of the chip at the nose of the tool increases as the depth of cut becomes equal to the traverse. With a tool having a straight cutting edge, and rounded at the nose, the intensity of pressure on the cutting edge must increase as the angle subtended by the curve increases. Therefore, when pressure alone is considered, the tool will be likely to fail at the nose rather than at the straight part of the cutting edge where the intensity of pressure is less.

When cutting metal at a high speed, a groove is formed on the top face of the tool at a little distance back from the cutting edge, due to the pressure of the shaving. This results from intensity of pressure, speed of cutting, and rise of temperature. When the groove extends to the cutting edge this breaks down. With a diminution in traverse, the crowding is less, and less heat is generated, while its dissipation is more rapid, and the tool has increased durability. As the traverse decreases and depth of cut increases, the cutting performance improves as the ratio of cut to traverse becomes greater or less than unity.

With regard to the second query: If the 90-deg. plan angle tool is compared with the others, the very large angle, and the small radius at the nose cause excessive crowding and heating, and the tool invariably failed at the nose. But with the round nose, with 2 in. radius, and the 30-deg. tool, each with a $\frac{1}{4}$-in. nose radius—the larger nose radius, with the smaller angle subtended, and the longer cutting edge engaged are in favour of a higher appropriate speed than is possible with the 90-deg. tool. In these respects the 60-deg. tool, lies between the others on the coarser traverses. This is attributed to a smaller angle subtended by the nose, a longer cutting edge, and a more favourable cutting angle.

It seems remarkable that the 30-deg. plan angle tool, while having the greatest durability, chattered badly on almost all cuts, while the 60-deg. tool caused little or no vibration. It was proved that the cutting speed decreases as the plan angle of the tool increases, for all cuts. The following figures show the average relative cutting speeds for these tools: 90-deg. plan angle tool, 1; 60-deg. plan angle tool, 1·21; 45-deg. plan angle tool, 1·48; 30-deg. plan angle tool, 1·87. (The 45-deg. plan angle tool is not shown in Fig. 1. It is

generally of the same form as the 60-deg. plan angle tool (41)). The results of the trials show that when the ratio of depth of cut to traverse is greater than unity, the 70-deg. cutting angle tool gives the greatest durability for a given cutting speed, but that when the ratio is equal to unity, a cutting angle of about 80 deg. is the most efficient, and allows of an increase in the cutting speed of about 8 per cent. above that of the 70 deg. tool. The relatively rough surface produced, and the increased power consumption for the 80-deg. cutting angle is likely to result in the 70-deg. angle being adopted for general workshop use (it is common now). It may happen, however, that the power available is such as to demand a more acute angle, in which case the permissible speeds for tools having angles of 50 deg. and 60 deg., are 71 per cent. and 82 per cent. of that for the 70-deg. angle tool, and these values are irrespective of the ratio of depth cut to traverse.

From a series of experiments made to determine the durability of tools having different cutting angles but with other conditions constant, it appears that an angle of 75 is the best. Others, to determine the best radius for the nose bear out the statement that the smaller the radius the greater is the intensity of pressure due to crowding, and therefore the appropriate speed is lowered. It was found that the cutting speed could be increased with the radius, attaining a maximum with a nose radius of $\frac{1}{8}$ in., then lessening as the radius was increased. For values of nose radius above $\frac{1}{8}$ in., the appropriate cutting speed has a minimum value when the radius approximates to the depth of cut. Where it is greater than the depth of cut, the cutting speed will increase with the radius, since a greater length of edge will be engaged. On the other hand, when the radius is less than the depth of cut, a portion of the cut is taken by the straight part of the cutting edge, resulting in less distortion and crowding, and greater durability. For radii of less than $\frac{1}{8}$ in. the capacity for dissipating heat is so slight that failure soon results. Another series demonstrated that for any one traverse, and radius, the speed decreases as the depth of cut increases, up to $\frac{1}{4}$ in., beyond which the approporiate cutting speed is almost constant.

Turning with a cooling medium instead of dry permitted of an increase in the cutting speed of about 20 ft. per minute. The coolant consisted of 1 part of soda dissolved in 50 parts of water, supplied at the rate of $1\frac{1}{2}$ gallons per minute. Experiments on tools with shanks of different sections simply demonstrated that the larger sections contribute to the life of the tools, with an increase in cutting speed, due to the more rapid dissipation of heat from the nose into the body of the tool. If the $1\frac{1}{4}$ in. square shank is taken as the standard in the speeds deduced from the experiments, then for tools of smaller sections, the cutting speeds can be obtained by multiplying the value for the $1\frac{1}{4}$ in. shank tool by the following factors: For $\frac{1}{2}$ in., 0·815; for $\frac{3}{4}$ in., 0·92; for 1 in., 0·97; for $1\frac{1}{2}$-in. shank the speed would only be about 2 per cent. greater than for the $1\frac{1}{4}$-in. shank tool.

A large number of experiments were undertaken to determine the component forces acting on a tool and the power consumed, under different conditions, while cutting. There were seven distinct series of these, in which all the variables of depth of cut and of traverse with tools of different plan and cutting angles were introduced. Measurements were taken with a dynamometer. The conclusions are too lengthy to be summarised here.

These elaborate experiments, with others that have preceded them are of value chiefly so far as they can be translated into shop practice. Do they add, we are inclined to ask, very much to the stock of shop experience? The forms of tools used are in regular use, mostly since high speed tool steels have come into service, being suitable for heavy cutting. The minute variations made in some of the conditions are rather confusing, and involve so much balancing and comparisons, as to repel the man who wants to ascertain quickly the best possible forms to standardise—for that is the way in which, out of a multiplicity of details and differences, tool forms must be crystallised. The trials should prove of most value to firms who standardise large quantities of their lathe work under uniform conditions of speeds, depths of cut and traverse, on mild steel of the approximate quality used in these experiments, which had carbon contents ranging from 0·22 per cent. to 0·514 per cent. The report does not include cast-iron, cast steel, nor any of the alloys. But within the area covered, it is a useful contribution to our knowledge of the subject of lathe tools.

THE HEAT TREATMENT OF NON-FERROUS ALLOYS.

THIS was the title of a lecture given by Professor F. C. Thompson at a meeting of the Sheffield Section of the Institute of Metals held on January 26. In his opening remarks the lecturer stated that, while an enormous amount of work had been done on ferrous alloys in order to determine the beneficial influence of heat treatment, very much less attention had been paid to that important question by non-ferrous metallurgists. Leaving out the subject of ordinary annealing after cold work, heat treatment could be applied to certain brasses and bronzes with results analogous to those obtained by similarly treating steel. Binary alloys which formed perfect solid solutions, such as the cupro-nickels, were as a rule not improved by quenching. In most cases their constitution did not lend themselves to such treatment. Considering, however, the 60 : 40 brasses (Muntz metal), which, on cooling, were composed of two constituents, both solid solutions, α in a matrix of β, Professor Thompson said that much could be done in the way of heat-treatment. Just as overheated steel could be normalised by suitable annealing, so could the coarse structure of over-heated Muntz metal be refined. The micro-aspect of the latter was analogous to the former, and showed excessively large angular masses of α in the β matrix. This brittle structure, often caused by casting at too high a temperature, could be corrected by annealing into the β zone, the correct temperature being read off from the thermal-equilibrium diagram of the system copper-zinc. The whole of the α disappeared and the single, homogeneous β solid solution was produced. On cooling, α reappeared, but in a much finer state of precipitation, rendering the material more malleable and ductile. The distribution of a constituent was as important a factor as the amount of that constituent present.

As was the case in the cupro-nickel series no structural change was brought about in α brasses by quenching; if, however, an $\alpha\beta$ brass were quenched from the β range, it should, theoretically, consist of this latter constituent alone. This, however, did not hold in practice; it had been found absolutely impossible to retain β unchanged, the microscope always revealed feathery particles of α at the crystal boundaries. Only in the case of manganese and other special bronzes had one been able to retain pure β by quenching. A 60 : 40 brass rod extruded while entirely in the β zone was of great interest microscopically, the cooling being rapid at the surface and becoming progressively slower as the distance inwards increased. The quickly-cooled outer surface showed a micro-structure consisting mainly of β having distinct "martensitic" markings. The metal a little further inwards consisted of "martensitic" β, together with a constituent corresponding exactly to troostite, the resemblance between this structure and that of a troosto-martensitic steel being nothing short of remarkable. The micro-aspect of the material furthest from the surface presented the appearance of a normal refined $\alpha\beta$ brass. Turning to the mechanical properties of quenched 60 : 40 brass, Professor Thompson showed that they bore a close relation to those of quenched steel. Generally speaking, the yield-point and maximum stress were increased and the elongation and reduction of area reduced by quenching from the β range.

Considering bronzes, the Professor added that, generally speaking, no structural changes could be brought about by quenching α bronzes. A 5 per cent. tin bronze, however, quenched from a temperature of 450 deg. C., showed an appreciable gain in mechanical properties, this doubtless being due to internal stresses, which, in this case at least, seemed to have a beneficial effect. Although the limit of α bronzes stood at about 13 per cent. tin, the microscope often revealed the presence of some of the δ constituent in an alloy containing only 9 per cent. of that metal. This, due to rapid cooling and consequent lack of diffusion, weakened the material, and correct annealing was the only way of normalising the structure.

A considerable amount of work had been done on the copper-aluminium series, and the quenching of various alloys gave results analogous to those obtained in the case of Muntz metal. The effect of "mass" on the properties of quenching an alloy containing some 10 per cent. of aluminium, as described by Carpenter and Edwards, was briefly referred to by the lecturer. Professor Thompson, in conclusion, dealt with the "ageing" of duralumin, and stated that this was an example of hardening by tempering, the process being carried out either by a comparatively short annealing at 200 deg. C. or by merely allowing the material to "age" at room temperatures—in reality a longer tempering at a lower temperature.

THE RAILWAYS OF THE UNITED STATES.

THE extreme difficulty of regulating railway rates is well illustrated in recent statistics from the United States, where the conditions which affected our systems after the war took a rather more extreme form. The scales of post-war wages rose to greater heights than with us; if anything, the trade depression following the fictitious boom touched greater depths. The condition of the railways on release from Government control was even less satisfactory than here, while the rate adjustment was more tardy in operation. Rate decisions were in fact deferred until a reduction based upon a period of good traffic was ordered when the railways, with wages still high, were upon the verge of one of the worst depressions experienced.

The Transportation Act of the United States allows the railways to earn a "fair return" on capital invested. The latter, on the basis of official figures would be about 20,000 million dols., on which the fair return, placed officially at $5\frac{1}{2}$ per cent., would amount to some 1,150 million dols. Instead of this, by dint of great economies, the railways managed in 1921 to earn a net revenue of 821 million dols., or 4·1 per cent. This, however, is vastly better than the previous twelve months, when with far heavier traffic a return of only 0·94 per cent. was obtained.

In the post-war period the returns showed the highest revenue from traffic to have been earned in October, 1920. There followed a rapid fall, made still worse last spring by the coal strike. Costs during this period were abnormally high, bulking so large in 1920–21 that the operating expenses represented no less than 91·54 per cent. of the operating revenue. By drastic economies and a curtailment of services enabling a reduction of 350,000 men to be effected in the staff, the companies saved the railways from utter collapse and brought the operating expenses back to the more reasonable, though still high, figure of 78·69 per cent. of the operating revenue. This is a rather remarkable change, in view of the falling-off in business, while the ordered reduction in rates did not make the railways' task easier. A subsequent reduction of wages when ordered was met by a strike which, though somewhat spectacular, did not have the serious effect first claimed for it. In any ordinary business prices and wages are regulated according to the markets. The more cumbersome form of control which it is now popular to saddle upon the railways, results in rates and wages nearly always being more out of phase with business than is the case in other industries.

A point which has arisen in the United States has been equally of interest to us here. It relates to the manner in which wages decisions and agreements work out as between industries. In the United States the railroads found that, with the scales they were ordered to pay, work in their repair shops was so expensive that many had recourse to letting much of this work out to contract shops, in which, as they were not under the control of the Railway Labour Board, but directly under industry instead, wages were less prohibitive. This move on the part of the railways was opposed by

the Commissioners, who contended that it was meant to remove a section of railway operation from their control. It was naturally opposed by the railway trades unions, and was one of the causes of the shopmen's strike of last summer. With the failure of the strike and other changes in the situation the object for the system was gone, and we believe it has now been discontinued.

The bearing which recent labour costs have had is indicated by the fact that of about 1,622 million dols. of increased revenue in 1921 as compared with 1916, two-thirds went in the increased rate of pay of 100,000 fewer employees. In the year 1921–22 the average pay of employees was 1,645 dols., compared with 825 dols. per man in 1915. For the first six months of 1921 pay had practically doubled for all grades below executive officers, as compared with 1916. In view of the habit of the labour mind to conclude, without reflection, that all the upper officials are always well looked after, it is interesting to note that the upper grades were actually in many classes of officials, earning less pay in 1921 than in 1916. In this interval all the subordinate grades had been advanced, some of them by no less than 250 per cent.

The 1921 (nineteenth annual) issue of the "Railway Statistics of the United States of America," edited by Mr. Slason Thompson and published by the Bureau of Railways News and Statistics, Chicago, tritely says that the American railways have other and more important functions than the payment of pay rolls and taxes. All railways, of course, have; for in addition they have to furnish the service required by the traffic offering, and to maintain themselves efficiently, so as to deal with the same and inspire the confidence of investors. With the latter object in view they have also to produce a reasonable return on capital. We have shown that the return does not yet approach to that set by the Commissioners as the basis of their regulation of rates and wages. It can equally be shown that maintenance is also much below the proper standard. For instance, the rolling-stock purchased in 1921 comprised only 1,185 locomotives, 1,636 passenger cars and 48,696 freight cars. These figures include the new stock for Canadian lines. It is reckoned that, on the normal scale of obsolescence for United States stock, at least 3,000 new locomotives, 2,000 passenger cars and 100,000 freight cars are required annually for that country by itself. The economies forced upon the railways by rates and wages regulations have prohibited effective replacements, so that on the expansion of traffic the companies cannot fail to find themselves greatly handicapped. In three years the number of freight cars retired from service has been 177,963, which is much below the normal figure, but is off-set by only 160,525 new cars commissioned. That maintenance of way is also falling behind may be gathered from the reduced output of steel rails in recent years, dating back to 1918, though 1920 showed a temporary improvement.

The immense number of persons interested in the management and maintenance on sound principles of the railways of the United States is indicated by the fact that stockholders alone number about 627,890. To these have to be added all the bondholders whose number has not been accurately computed. The total, however, is estimated to exceed by a good many thousands the number of the employees who themselves total about 1,700,000. Many receiverships in the case of American railway companies date back a good many years. At the present time the mileage of systems in the receivers' hands amounts to 14,502. The increase during the year 1921 represented some 1,744 miles. Three of the smaller roads applied for permission to go out of business altogether. In addition, operation was discontinued on 1,677 miles of line by other companies, making a total for the last five years of 5,647 miles of line on which services had been suspended. Much of this has been definitely abandoned and the track taken up. To offset this no more than 475 miles of new line were built last year in a country which is clearly yet a long way from being fully developed. In good times before the war construction amounted to between 4,000 miles and 6,000 miles in a year, and though such rates cannot be permanently maintained there is a great difference between that and the minimum of 314 miles built in 1920, or even the figure for 1921. The fact undoubtedly is that the situation has been too unstable to encourage new enterprises which have as a consequence been curtailed to the utmost degree.

The grouping or consolidation of the systems provided for in the Transportation Act has not yet made very much headway. While in this matter we have made very considerable progress, in the United States there is still indecision as to the direction consolidation should take in many instances.

In connection with rate regulation a valuation of the railways by the Government was inaugurated in 1913, when the general official or political view was that it would disclose considerable inflation. Up till the present there is, however, every indication that the final Government figures will exceed those originally put forward in railway circles. The valuation was expected to take about four years. It has now been proceeding for ten, and so far only one final valuation has been made, namely, for the Evansville and Indianapolis Railway.

PATENT AND TRADE-MARK ACTIONS OF 1922.

During last year the patent, design and trade-mark cases reported numbered 51. Of these many of the patent actions are of interest to engineers generally, but the design and trade-mark actions apply to other branches of industry. Four patents were held valid, application for revocation was refused against one patent, four patents were held invalid, an application for extension was refused in one case and 18 patents were extended. Some of the decisions referred to above are open to appeal.

Damages.—An important decision was given in connection with damages due to infringement according to which the infringers of a patent in Scotland were held to be liable for damages between the date of a judgment of the English Court of Appeal holding the patent invalid and the date of the reversal of that judgment by the House of Lords.

Applications for Extension.—These comprise a most important part of the patent actions reported since the war because of the new procedure by way of originating summons for extension of a grant on the ground of loss due to hostilities. Du Rhone's patent in connection with the charging of anæsthetic liquids into tubes or vessels was extended for four years on it being proved that the applicants had suffered loss within the meaning of the appropriate sections of the Acts.

Hunt's patents for alternating current dynamo-electric machines, that is, the Cascade patents, were extended for four years from the termination of the earlier patent notwithstanding the fact that the remuneration received had been considerable.

Howatt's patent for mineral washing and separating apparatus was extended for four years, subject to an undertaking which was given by the applicant that a certain verbal agreement into which he had entered should be embodied in a deed and registered so that it could be publicly inspected.

Drew's patent is the case of an expired patent extended, the extension granted being for 3½ years, on the ground of loss due to the war, a new patent being issued on the ordinary conditions as to licences and the usual restrictions.

Creighton's patent was extended for three years, Renard's patents for four years, and the Austin motor patents for four years and three months, all on the ground of loss suffered by reason of hostilities.

The Duncan and Pierpont patents which related to machinery for the manufacture of matrices were extended for three years although expired, applicants having been engaged in the manufacture of munitions throughout the war and the manufacture of matrices practically suspended.

Smith's patents relating to fire and temperature alarms were involved in an application for extension in which it was suggested that there were such exceptional circumstances that a longer extension than the commonly limiting period of five years for an extension under the usual conditions should be granted. Evidence was given that the petitioners' device which practically consisted in a continuous tension member of high tensile material with loops in a mechanical multiple element type of fire alarm was more simple in construction, less expensive to install and maintain and was more reliable than any previous system. The patentee had been hindered in exploiting the patents by causes due to hostilities and by being unable to obtain the certificate of the Fire Offices Committee for many years. The application involved a new point, namely, the plea that the words "exceptional cases" which are contained in the Act as being necessary to the grant of an extension for more than five years did not in all instances import exceptional merit. It was held by the learned judge that the main element in determining whether a case was an exceptional case was the element of merit, but that although the phrase was a wide phrase without exceptional merit the grant of an extension of more than five years could not be justified. It was therefore decided to extend both patents for a period of five years from the date of expiry of the first patent.

Patents to Young of 1906, Brown, Coleman and Johnson, were also extended for periods varying from one year to the full term of the war, namely, four years and three months.

One of the latest cases is one of the most important and dealt with the Fullagar engine patents. In this application an extension of the patent was granted on a petition filed longer before the expiry of the patent than any other petition had been successfully lodged. It was found that the engines made under the patent were very costly to construct, and that there could not be any substantial profit to the patentees before the expiry of the patents.

Gresley's patent for railway and tramway vehicles was extended for the full period of the war because it was proved that loss had occurred owing to the cessation of coach building and the manufacture of munitions by railway companies during the war, and to the fact that the inventor's time was fully occupied in his duties with the company so that he had been unable to bring the invention to the notice of other companies.

Infringement.—The most important newly-decided case under this heading is probably that of the British Thomson-Houston Company, Limited, in respect of their patent for leading-in wires coated with a metal, the oxide of which is soluble in glass or the like at a low temperature such as a tungsten wire coated with copper.

The defendants to the action contended that the patent was invalid for want of novelty, subject-matter, utility and ambiguity, particularly because it did not give any directions as to whether the expansion of the wire was to be measured radially or longitudinally. It was held that the patentee must have been referring to the lateral expansion of the wire and not the longitudinal expansion, and that the patent was infringed.

Subject-Matter.—An important decision was given by the House of Lords on Schoop's patents for the welding of aluminium by the use of a flux consisting of a mixture of alkali chlorides and sometimes with a fluoride. Considerable argument was involved in this case largely on the basis of a disclosure in Roscoe and Schlorlemmer's "Chemistry," which described melting of pieces in a crucible. It was subsequently held that there was subject-matter in applying to welding aluminium the flux formerly used for soldering, and that this was not affected by the melting process disclosed.

THE SUPER-POWER STATION.

A Joint Meeting of the Midland Branch of the Institution of Mechanical Engineers, of the Birmingham and District Association of the Institution of Civil Engineers, and of the South Midland Centre of the Institution of Electrical Engineers, was held in the Council Chamber, Birmingham, on January 25, 1923, to discuss "The Advisability of Limiting to Super-Power Stations the Public Supply of Electricity." Mr. L. Pendred, Member of Council of the Institution of Mechanical Engineers, occupied the chair, and the discussion was opened by Sir Vincent Raven who, speaking he said, as a railway engineer, was convinced that unless electric energy could be supplied at a much cheaper rate than was usual in this country to-day many would find it impossible to utilise electric power, in spite of certain subsidiary advantages. This was undoubtedly the case with the railways. No hard and fast rule could be laid down as to how cheaper supplies were to be secured,

but in the course of an inquiry held in London in 1922, it appeared that many large power companies were prepared to supply at about ½*d.* per unit. Super-power stations, if the term was meant to imply that all electric needs were to be supplied by a limited number of such stations distributing through trunk mains, were, he thought, impossible, owing to the capital costs involved, but on the other hand, the maintenance of a number of small stations dependent on cooling towers for their condensing water was inconsistent with cheap power supply. He thought that large stations with at least 15,000 kw. to 20,000 kw. capacity should be installed in carefully selected situations, and should be capable of producing electric energy at a coal consumption of not more than 2 lb. per unit, a figure which was at present attained in but very few cases. After careful consideration he had come to the conclusion that even such large undertakings as railway companies should purchase their supplies in preference to having power stations of their own, and whilst, as stated, not in favour of a limited number of super-power stations, he held that separate power stations should be encouraged in large industrial areas, the smaller stations being gradually abolished and coal economy enforced, if necessary, by legislation. The best plan yet produced was that which had been adopted in the North-East Coast area, but whether by the instrumentality of private enterprise or by a joint electricity authority, he held that all generating stations and main transmission lines in an electrical area should be centralised. In evolving a system of linking up, existing stations might be helpful as a first stage, but their use should not interfere with the construction of new and better stations. Some progress had already been made, and whilst in old stations the standard operative conditions were based on steam supplied at 200 lb. per square inch and at 550° F., with a 28½ in. vacuum, these new stations were intended to operate with steam at a pressure of 300 lb. and at a temperature of 700° F., the vacuum being 29·1 in. With these large new plants a steam consumption of 17,000 B.Th.U. per unit was a practical figure, and in specially favourable conditions it might be as little as 14,000 B.Th.U. per unit. The cost per kw. installed was low owing to the large size of the boilers and generating machines, whilst the large area covered, which was seldom less than 25 acres, made practicable any new method of dealing with the coal before using it for the boilers. It was, he added, a waste of money to extend ill-placed stations, even if estimates showed that for some time to come such an extension would give a better result than the taking of a bulk supply. The large stations, he added, must anticipate the future. Had it not been shown that certain supply companies would soon be in a position to supply current to the South-Eastern and Chatham Railway at a price not greater than that company could generate for themselves, still another station would have been erected in the London area.

Mr. Alfred Dickinson, who spoke next, said that in the interests of the community super-power stations should be allowed to supply energy directly to any consumer in their district. In his view, the supply and sale of electricity should be as free as the sale of any commercial or manufactured commodity, and he held that no undertaking should depend for its success on its legal monopoly, rather than on its intrinsic merits. He believed that in the near future coal would not be fired direct to the boilers of large power stations, but treated first for its by-products. In favour of his view that competition should be free, he quoted a case in which a super-power-station was opposed by an existing company, but got their powers nevertheless, with the result that 70,000 h.p. was being supplied at about 300 per cent. less cost than it was practicable for the opponents of the new station to do. Consumers were thus obtained who could not have taken the energy at the rates previously in vogue. He believed that, given freedom of supply and the abolition of county and municipal boundaries, electric energy would be generated largely as a by-product, and sold at a price which would justify its general use for power, lighting and cooking. In all conditions, however, the supply should be provided on strict commercial principles. In some cases to-day current was being sold under cost, but he held that in all cases the charges should cover at least actual works' costs, and the capital charges.

Mr. R. G. Chattock, who followed, said that he could not endorse the view that the public supply of electricity should be limited wholly to super-stations. This suggestion was evolved by the lay press from a misunderstanding of the recommendations of the Electric Power Supply Committee. The development of super-stations should provide for utilising the older stations for the taking of intermittent and peak loads, which were only felt for a few hours during the day, and the bulk of the supply during each 24 hours should be taken from the more modern stations. Mr. Chattock gave the following table showing average costs for stations of different capacities, the last line being the estimated figures for the Nechells station at Birmingham, which is to have an ultimate capacity of 105,000 kw.

Average Capacity of Plant Installed.	Works' Cost per unit generated.	Station Cost per unit generated, including Capital Charges.	Total Cost per unit sold, including Capital Charges, Rates, Taxes, Management, Transmission and Distribution.
Kw.	*d.*	*d.*	*d.*
114,000	0·87	1·27	1·95
51,000	0·88	1·39	2·32
20,510	1·27	1·81	2·70
5,375	1·80	2·53	3·87
1,000	2·14	3·02	—
575	2·73	3·82	—
520	2·04	3·12	—
105,000	0·208	0·44	—

The figures showed, he said, that even when the cost of transmission and distribution was included, the large stations could easily beat the small one. The earlier groups included older and less economical stations than were now being erected. It would be noted that the capital charges for the Nechells station were only about one-third of the average cost of the older stations referred to on the first line of the table.

Lieutenant-Colonel Kitson Clark said that owing to the circumstance that not all the coal brought to bank was suitable for steam raising, an ordinary colliery producing half a million tons of coal per annum would only serve to supply a station of 10,000 kw. capacity. He thought that super-stations should be built in 50,000 kw. units. With modern large boilers and large units it appeared that 5 kw. of generating plant and 3 kw. of steam-raising plant could be accommodated per square foot of ground, so that the boiler room was greatly in excess of what was needed for the generators. Since very few mines could supply all the coal required for a large station, coal would have to be transported, and there was thus no good reason for locating generating stations at or near a pithead. In his view the best plan to follow was to generate current where you could, and to link up the different sources of supply.

Mr. J. H. T. Legg said he had no doubt but that large stations would lead to cheaper supplies of current. He had recently gone into figures for a small station. Such stations, during the few hours of the day in which the industrial load was on, generated quite cheaply; but he found that the cost per unit was astonishing during the rest of the day, being three, or even four times the average figure. One difficulty in connection with large power stations was the question of wayleaves. As matters stood the Postmaster-General could at any time demand that an overhead transmission line should be placed underground, and the danger of an unreasonable exercise of this power had done more than anything else to discourage the supply of current to rural areas.

Sir Henry Fowler thought that the questions involved were such that the meeting should have been strengthened by the presence of members of the Institute of Accountants and of the London School of Economics. He stated that in 1919 he had visited a super-station near Cologne. This was run with brown coal obtained from three large collieries in the neighbourhood. The plant comprised six 15,000 kw. units, and still larger units which were not running at the time of his visit. He was satisfied that it was more economical to produce current in stations of the largest size, and common sense showed where they should be situated. There were, however, special cases, where steam was used for other purposes than generator-driving, in which it was more economical to have a small private station than to take supplies from a super-station.

Mr. S. T. Allen said that he thought a wrong impression would be given if it were suggested that municipal plants did not write down their electrical plant as time went on. In fact, they had to do it in a much more definite way than the companies were required to do.

Major A. M. Taylor dealt with the question as to whether it was cheaper to transmit power or to transport coal. Taking the distance of transport as 30 miles, then if 2·75 lb. of coal were required per kw.-hour, and if the freight were 1·2*d.* per ton-mile, the cost of coal transport would work out at about 0·044*d.* per kw.-hour. If, however, a voltage of 100,000 kw. was adopted, 50,000 kw. could be transmitted by cables for a distance of 30 miles at an initial outlay, for cables only, of 0·266*l.* per kw. per mile. By using heavier copper, 100,000 kw. could be transmitted for an initial cost of 0·17*l.* per mile. Cable makers were now prepared to supply cables to work under a maximum potential gradient of 50,000 volts. per cm., and this would allow of the current being transmitted at 150,000 volts. Under such voltage condition, 200,000 kw. could be transmitted by the same number of cables, thus bringing down the initial outlay on cables to 0·085*l.* per kw. per mile, which, taking interest and sinking fund charges at 10 per cent., would involve a charge for a 30-mile transmission of only 0·018*d.* per kw.-hour. Adding the charges due to losses in the line and in the transformers, the total cost for transmission would be 0·043*d.* per kw.-hour, as compared with 0·044*d.* for coal transport. The estimate for the latter, however, did not include the costs of sidings, stores, and ash removals, which were high in stations situated near large towns.

Professor Cramp suggested that a power station could not supply energy to a colliery having slack worth 5*s.* or 6*s.* per ton at as low a price as it could be generated on the spot. He thought it would be a mistake to give a monopoly to super-stations, and that individuals should be allowed to supply themselves if they so desired. He instanced a case near Birmingham where a large works, having its own generating station, wished to convey current across the road to another part of its works, and were unable to get permission to do this.

Mr. J. C. Vawdry said that power stations should be developed to deal with special districts, such as manufacturing areas, where there was a large demand for current. In his opinion there were areas, such as Cornwall and Devon, where it would not pay to erect large power stations.

Mr. Selby disagreed with Sir Henry Fowler as to the value of the opinion of the accountant or the financier on the matter under discussion. An accountant only considered the immediate present, and attached no value to potentialities, but demanded an immediate return on all outlay.

Professor Lea, who followed, concluded that at a super-station, power would not be developed with an expenditure of less than 2 lb. of coal per kw.-hour. He thought it possible that within a few years internal combustion engines might be able to develop one kw.-hour with much less than this figure—perhaps as little as 1 lb. of coal per unit. If this were possible a start would be made with small units, and larger ones would be gradually developed. If electric energy production were confined to large stations, developments of this kind might be checked. The question of hydro-electric plants also had to be borne in mind. At Fort William it was proposed to build such a station, developing 100,000 h.p.

In bringing the discussion to a close, Mr. Pendred recalled the fact that in the report issued last year by the electricity commissioners, the lowest fuel consumption was shown by a small plant at Launceston, which took only 1·7 lb. of fuel per unit generated, the corresponding figure for Carville being 1·78 lb. At Launceston, however, the fuel used was anthracite, which was consumed in a suction gas producer. At Carville, ordinary steam coal was used, so that relatively speaking, the advantage lay with the large steam-driven stations.

THE INTERNAL STRUCTURE OF CRYSTALS.

ILLNESS unfortunately prevented Sir William H. Bragg, F.R.S., from appearing in person to deliver the fifth "Trueman Wood" lecture at the Royal Society of Arts on Wednesday, January 24, and Mr. Alan A. Campbell-Swinton, who was to have presided, was unable to be present from a similar cause. The lecture, entitled "New Methods of Crystal Analysis and their Bearing on Pure and Applied Science," was therefore read by Mr. G. Shearer, of University College, who has been closely associated with Sir William in connection with his investigations into crystal structure. Very little was said about the methods employed in studying crystals, the lecture being devoted mainly to a discussion of the nature of the constituent molecules and their arrangements in the crystal. There were hardly any new facts to be announced, but the intrinsic interest of the subject, coupled with Sir William Bragg's power of lucid exposition, held the close attention of the audience.

It was accepted by all chemists and physicists that the natures of all materials were dependent upon the properties and arrangement of their ultimate constituent atoms, of which there were some 90 different kinds. The problem was to find out how any particular characteristic of a substance was correlated with its atomic and molecular structure, and this could only be done by investigating the nature and arrangement of the atoms and of the molecules into which they were grouped. The molecules of gases were practically independent of each other, and when the gas was condensed to a liquid the molecules still had a large amount of freedom. In a solid, however, the molecules were tightly packed together, and they tended to arrange themselves in a regular repeated geometrical pattern. When this occurred the substance had a crystalline structure. The symmetry of the arrangement, in a sense caused the individual molecules to lose their identity, as there was no reason why any particular atom should be considered as belonging to one molecule more than to some other. The diameter of an atom was only about one two-thousandth of the length of the light waves which affected our eyes, and thus atoms could never be seen in the ordinary sense. This would be fairly obvious when it was recollected that both the lenses of the microscope and our own eyes consisted ultimately of groups of atoms in juxtaposition.

Although atoms were so small that ordinary light waves were useless in investigating them, the use of X-rays, which differed only from ordinary light in the fact that they had a wave length of only about one ten-thousandth as much as that of light, enabled us to study the arrangement of atoms in crystals and to measure the distances between them. It was now quite certain that crystalline carbon, or diamond, consisted of an arrangement of units of carbon atoms, each unit being formed of five atoms, of which four were arranged at the corners of a tetrahedron and one at the centre of the latter. The hardness of the diamond was due to the closeness of the packing which the arrangement permitted, and to the simplicity of the structure. A structure built up of tetrahedrons of this kind would be seen to have planes of cleavage, along which shear could take place relatively easily, and this was a property well known to diamond cutters. By removing a layer of carbon atoms as found in the diamond structure, and then giving a definite twist to the layer, another stable position could be found for it. The connection with the adjacent layers was then vastly weakened, and the structure was that of graphite, which owed its lubricating properties to the ease with which its atomic layers could be sheared.

The structure of each layer of carbon atoms in either diamond or graphite was that of a hexagonal pattern with atoms at the corners. The atoms of each layer were not quite in the same plane, so that the hexagons were crinkled. This hexagon formation of carbon atoms was wonderfully stable, and was associated with the well-known stability of the similar arrangement in the molecules of benzene and its derivatives. Ice also had a hexagonal structure, the results of this being beautifully evident when snow crystals were examined under a microscope. The ice structure, however, was comparatively open, with large interstices, the form being demonstrated by a model exhibited by the lecturer. Many other models of molecules were shown, the atoms, the dimensions of which were said to be known to an accuracy of about one part in a thousand, being represented by balls connected together by rods which held them in their relative position. By means of such models the author demonstrated the details of the chemist's work when he built up synthetic compounds. The nature of the molecules of substances which rotated the plane of the polarisation of light was explained, such molecules having a spiral arrangement of their competent atoms. In the case of quartz the spiral might be either right or left-handed, the two systems corresponding respectively to the two forms which the crystal might assume.

THE LATE HON. R. C. PARSONS.

A WELL-KNOWN figure in engineering circles has been removed by the death of the Hon. Richard Clere Parsons, which occurred at his London residence last Sunday. Mr. Parsons, who was born in 1851, was the third son of the third Earl of Rosse, and must from his earliest years have lived in an atmosphere of interest in science and mechanical things. His father was a scientific man of eminence, and was for some time President of the Royal Society, while his name will always be remembered in association with the famous reflecting telescope which he constructed and erected at Birr in King's County, Ireland. It was at Birr, or Parsonstown, by which name it is also known, that Richard Parsons was born and spent the early and impressionable years of his life. There were four brothers in the family at Birr of which, as we have already said, Richard was third. The youngest brother was Charles Algernon, who as the present Hon. Sir Charles Parsons would require no introduction in the pages of any engineering journal throughout the world.

The Parsons boys were educated at home, and had at one time the benefit of tuition from the late Sir Robert Ball, while their scientific interests are likely to have been fostered by coming in contact with the many scientific men who were attracted to Birr by the famous telescope. After this education at home, Richard, in 1869, passed on to Trinity College, Dublin, where he became Senior Moderator and Gold Medallist in physical science and chemistry, and took an engineering degree with honours in 1873 at the age of 22. He then was apprenticed to Messrs. Easton and Anderson, and remained with the firm until 1877. During his apprentice days, in 1875, he joined the Institution of Civil Engineers as a student and received the Miller Scholarship for a paper on "Centrifugal Pumps," in 1876. This early interest in this type of pump was retained throughout Mr. Parsons' life, and in later years he introduced several important inventions connected with pumps of this class. He became an Associate Member of the Institution in 1876, and a full Member in 1883, while he joined the Institution of Mechanical Engineers as a Member in 1878.

After the termination of his apprenticeship, Richard Parsons was first engaged as resident engineer, under Mr. Edward Easton, on the South Hants Water Works, and was thus early brought in touch with another branch of work on which he was destined to be largely engaged in later life. He was then occupied with various designing and erecting work for Messrs. Easton and Anderson, and in 1880 became a partner in the firm of Kitson and Co., Limited, of Leeds. It was while Richard was with Messrs. Kitson that the firm constructed several examples of the rotary steam engine which was one of the earliest inventions of Sir Charles Parsons. Richard Parsons remained with Messrs. Kitson until 1887, and in that year he stood for Dublin University as an independent Conservative candidate. He was defeated and did not, we think, at any time again make any attempt to enter Parliament. During his connection with Kitson's he was closely associated with the development of Yorkshire College, which has now become the University of Leeds.

In 1887, at the age of 36 years, Mr. Parsons began the consulting practice which he continued until his death. In that year he went into partnership with the late J. F. La Trobe Bateman, whose daughter he married. His consulting work was in the main concerned with works executed abroad, although from 1893 to 1895 he was engineer to the Congested Districts Board for Ireland. Among the important foreign works with which he was connected, the complete water and drainage works of the city of Buenos Ayres may be mentioned, as well as the detailed scheme he prepared in 1898 for the drainage of Petrograd. Mr. Parsons had many definite consultative appointments abroad, and was engineer to the Consolidated Waterworks Company of Rosario, Limited, and to the Montevideo Waterworks Company, Limited. It was in connection with this consulting work for the Waterworks Company of Rosario that Mr. Parsons designed the apparatus known as the Tiltometer, the purpose of which is to add a coagulant to a water supply before filtration. The apparatus is automatic, and supplies a fixed percentage of the salt to the raw water. This apparatus was described and illustrated by us in our issue of March 29, 1912. The Tiltometer was followed a year or so later by another device of Mr. Parsons, which was intended to carry out the same work, but was capable of adding the salt to water under pressure, for which the Tiltometer was not suitable. The second device, which is known as the Senfrot, was described and illustrated in our columns on December 11, 1914.

These two devices by no means represent the total results of Mr. Parsons' inventive ability, and while it would not be possible to give a list of all the various mechanical appliances he introduced, some mention should be made of the Stereophagus pump which has become probably the best known of them all. This pump, which was introduced about 1911, was described in our issue of April 5, 1912. It is intended for pumping sewage or very dirty water, and contains a series of spiral blades which cut up any solids which may be present, so that choking is prevented. The action is something like that of an ordinary lawn-mower. Mr. Parsons read a paper entitled "Centrifugal Pumps for Dealing with Liquids Containing Solid, Fibrous or Erosive Matters," before the Institution of Civil Engineers in January, 1919. In that paper he described the Stereophagus pump, and also a later centrifugal pump of his invention which is known as the Flexala. This latter pump is intended particularly for dealing with liquids containing erosive substances and has a rubber impeller and special vulcanised rubber protection for parts liable to wear. The latest developments of this pump, together with a modification of it, known as the Resiline, were described and illustrated in our issue of January 20 last year.

Mr. Parsons always took much interest in the higher educational work, and his early association with Yorkshire College was reflected in later years in the fact that at the time of his death he was Treasurer and Deputy-Chairman of the Delegacy of King's College of the University of London, and a Governor of the Imperial College of Science and Technology, being nominated by the University of London. He was a Vice-President of the Royal Society of Arts and was also a Vice-President and Manager of the Royal Institution. He took little part in the activities of the Institution of Mechanical Engineers, but read many papers before the Institution of Civil Engineers, and received the Telford Gold Medal, the Manby Premium and the George Stephenson Gold Medal. He was also a member of the Société des Ingenieurs Civils de France.

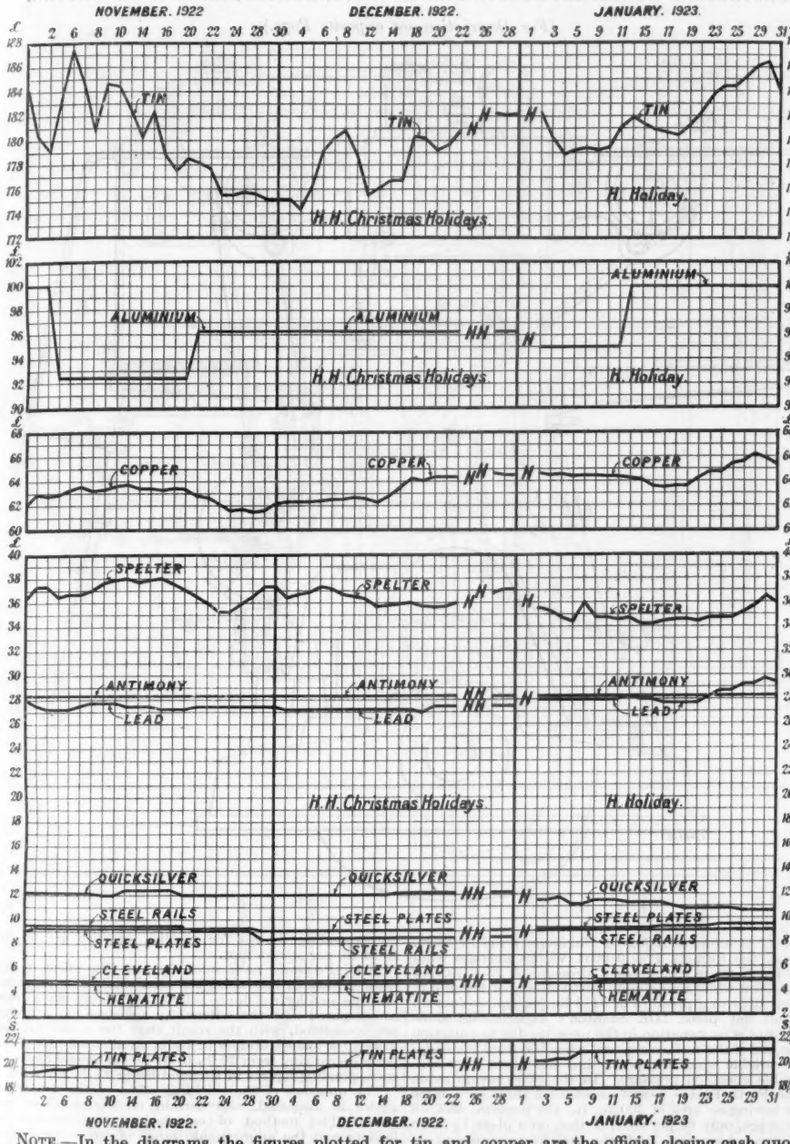
SOUTH FRANCE INTERNATIONAL EXHIBITION.—An International Exhibition, having the support of the municipalities of Bayonne and Biarritz, and the Board of Trade of Bayonne, will be held during the months of July, August and September. Further particulars can be obtained from the Commissaire Général, Exposition Internationale, Bayonne Biarritz, 1923; Hotel de Ville, Bayonne (B.P.), France.

THE INSTITUTION OF CHEMICAL ENGINEERS.—The first meeting of the Provisional Council was held on Wednesday, January 10, at 186, Piccadilly, London, W.1. The solicitor reported that he had received from the Board of Trade the Certificate of Incorporation and the order of the Board of Trade, giving authority for the Institution to commence work. Sir Arthur Duckham was elected unanimously the first president of the Institution and Messrs. K. B. Quinan and C. C. Carpenter were unanimously elected the first vice-presidents. Professor J. W. Hinchley was elected honorary secretary, and Mr. F. H. Rogers honorary treasurer. It was decided to hold the first annual corporate meeting of the Institution on March 14, at 3 p.m., in London.

THE MANUFACTURE OF SAFES AND STRONG ROOMS.—An interesting cinematograph film illustrating the construction of a modern bankers' strong room door at the Wolverhampton works of Messrs. Chubb and Son's Lock and Safe Company, Limited, was shown to a large gathering of press representatives and others at a luncheon given at the Hotel Victoria, on Thursday, the 25th ultimo; the luncheon was presided over by Sir George Hayter Chubb, Bart., the chairman of the company. The film illustrated the manufacture of the manganese steel for the door and frame, and also the processes of moulding, cleaning and machining the castings as well as the work of finishing and fitting up the door. An interesting feature was a demonstration, in one part of the film, of the resistance of the Chubb alloy steel to the action of the cutting flame of the oxy-acetylene blowpipe. A blowpipe flame which cut through a plate of ordinary steel almost instantaneously was applied to a plate of the special steel for some considerable time with little or no effect other than local heating. The technical features illustrated by the film were dealt with in a paper read before the Royal Society of Arts on December 6 last, by Mr. Emory Chubb, and a reference to this paper will be found on page 737 of our last volume.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

INDUSTRIAL NOTES.

THE following figures are taken from *The Railway Mechanical Engineer*, New York: "The general proportions of locomotives are usually based on the assumption that 120 lb. of coal will be burnt per hour for each square foot of grate area. Typical modern Mikado or Pacific type locomotives usually have from 60 sq. ft. to 70 sq. ft. of grate and would, therefore, require 7,200 lb. to 8,400 lb. of coal per hour. The limit of hand-firing is about 7,500 lb. per hour, but the best that can be expected from the average fireman is about 6,000 lb. It is natural for the fireman to spare himself as much as possible, and in everyday service the rate of firing will usually not exceed 3,000 lb. to 4,000 lb. of coal per hour while a locomotive is running. This means that the fire-box is getting less than half the amount of coal it can use and the cylinders are getting only about half the amount of steam they were designed for . . ." These figures, of course, relate to American practice.

We commented on page 72 *ante* upon a statement concerning doles contained in the January report of the United Society of Boiler Makers and Iron and Steel Shipbuilders. The fact that the system of doles requires amending is confirmed by the following: At a meeting last week of the Glasgow Shipowners' Association, Mr. W. S. Workman stated that one of his firm's steamers went into dry dock on Monday night, January 22, and they were anxious she should be out again in time to take her cargo and bunker coal before sailing on Saturday following. Although the ship was dry and ready for painting at 8 o'clock on Tuesday morning, and the weather was perfect for such work, at 11 o'clock the shipbuilders informed them that they could secure only 12 men to paint her. When they pointed out that that was absurd in view of the unemployment in the city, and that the vessel must leave dry dock that afternoon, the shipbuilders replied that they could not get more, as that was the day the men were collecting their doles.

The doles have been the cause of a strike at Liverpool. In this instance, 200 men at Hamilton Ironworks went on strike following a dispute between the management and the men's union. The management wanted to keep all men working during the slack period by taking on each man three-quarter time, whereas the union insisted on the men being alternately employed full time, so as to have the dole during the unemployed periods.

An article by the Hon. F. M. B. Fisher in the current issue of *Imperial Commerce* states that the system of doles is a popular abomination; "it has become largely a bonus to those to whom the very suggestion of work is almost offensive."

The Federation of British Industries has for some time past been the object of attacks on the ground that it is conducting a campaign for the lengthening of working hours and the reduction of wages. In view of these attacks the Federation wishes to state categorically that any such suggestion is utterly untrue. The federation is precluded by its constitution from taking any part in regulating the relations between employers and employed. It deals solely with commercial, financial and technical questions, in regard to which it promotes the interests of its members, and therefore also of their workpeople. Questions affecting the relations between employers and employed are dealt with by other and completely independent parties.

Mr. J. R. Clynes, M.P., presided last Friday over the first joint London meeting of the committee appointed to give effect to the ballot of the members of the organisations concerned on the proposed amalgamation of the National Union of General Workers, the Municipal Employees' Association and the National Amalgamated Union of Labour. It was reported that in the ballot of the three unions there voted:—

For amalgamation	....	....	232,723
Against amalgamation	....	....	14,060
Majority in favour	....	....	218,663

The meeting thereupon resolved to call upon the three unions now to appoint representatives to form the first executive, which will be empowered to frame rules and give effect to the scheme of amalgamation and submit the rules to a conference.

Active conditions prevailed at the weekly meeting of the London Iron and Steel Exchange on Tuesday last, and the attendance was a large one. A considerable improvement in business was reported from practically all the British steel-making districts, whilst it was stated that depressing accounts had been received from all the Continental producing countries. Several French and Belgian works were understood to have closed down from lack of fuel; whilst a Luxemburg works, which some time ago purchased British coal at a high figure, was in the market at much enhanced prices. Enquiries for pig-iron from Continental countries had been circulated of late, and although the resulting orders had not been individually large, in the aggregate they amounted to a good tonnage.

THE LATE MR. CHARLES LOUIS FAULKNER.—We regret to have to record the death, which occurred on January 20, at his residence, 2, The Orchard, Blackheath, S.E. 3, following upon a serious operation, of Mr. C. L. Faulkner, director of Messrs. Bolling and Lowe, Limited, 2, Laurence Pountney Hill, E.C. 4. Mr. Faulkner was 55 years of age. After completing his education at Colfe Grammar School, Lewisham, he entered the firm of Messrs. Bolling and Lowe, the well-known engineers and merchants. In the year 1902, he started on his own account in the city and rapidly established business connections both in this country, the Colonies and abroad, dealing mostly with rolled iron and steel material. In April, 1918, at the solicitation of Messrs. Bolling and Lowe, Mr. Faulkner returned to them as a partner, and on his initiative the concern was transformed later into a private limited company, of which he was director up to the time of his death. Mr. Faulkner was one of the founders of the London Iron and Steel Exchange, of which he was director; he was also a member of the iron and steel section of the London Chamber of Commerce; a member of the Birmingham and Glasgow Exchanges and of the Iron and Steel Institute. He was a freemason and one of the founders of the Vulcan Lodge, of which he was Past Master and held London rank; also a founder of the Hardware Lodge. Mr. Faulkner was held in very high esteem in all metallurgical circles both in the United Kingdom and on the Continent; he was a very capable and alert business man, with whom it always was a pleasure to deal. His most genial disposition had won for him a wide circle of friends.

SYMBOLS FOR ELASTIC CONSTANTS.

To the Editor of Engineering.

SIR,—May I, through the medium of your Journal, ventilate a grievance which all who follow the profession of engineering must have felt when dealing with the symbols allotted to the elastic constants by various authorities. No student of engineering can restrict his reading to one particular text-book, and the diversity of symbols employed by leading writers makes a wide reading tedious and unnecessarily involved. I append a list giving the symbols for the three elastic moduli and for Poisson's ratio used by five widely-read writers. The choice of the fractional symbol for the ratio is particularly unfortunate, altering as it does the usual appearance of several well-known formulæ. Possibly the desire to avoid the charge of plagiarism is partly responsible for the confusion of symbols, although the authors are eminent enough to be beyond any such charge. With all deference, may I suggest that future writers either use the symbol adopted by the majority of engineering authorities or use those given in the "Encyclopedia Britannica."

Authority	Ewing	Morley	Barton	Low	Andrews
Moduli:					
Tension (Young's)	E	E	q	E	E
Shear	C	N	n	C	G
Bulk	K	K	k	K	K
Poisson's ratio ...	$\frac{1}{\sigma}$	$\frac{1}{m}$	σ	σ	η

Yours faithfully,
W. ABBOTT.

17, Cromwell-road, Rosyth, Fife, N.B.,
January 28, 1923.

WIND PRESSURES AND STRESSES CAUSED BY THE WIND ON BRIDGES.

By DOUGLAS HENRY REMFRY, Assoc.M.Inst.C.E.

THE Indian bridge rules specify an allowance for wind pressure of 56 lb. per square foot, on unloaded structures and 33½ lb. per square foot on loaded structures. There is a general tendency now to consider these allowances as being too high. The author concludes that they may be considerably reduced for unloaded spans, but that very slight reductions, if any, should be permitted for loaded structures in India, though in England a further reduction might be allowed. It has been usual in the British Isles to take the maximum wind-pressure on an unloaded structure as 56 lb. per square foot of surface exposed. This high value was thought necessary when the profession was greatly disturbed by the Tay Bridge disaster, and has led to a very high expenditure on large bridges. As an instance, in the Forth Bridge the weight of metal provided to resist wind stresses is nearly three times as great as that necessary to sustain the live load.

There is no doubt that the committee appointed soon after the Tay disaster to consider the question of wind pressure on railway structures was incorrectly informed as to the velocities corresponding to the records obtained in England with the Robinson anemometer. It was usual to assume that the actual velocity of the wind was given by multiplying the velocity of the revolving cups by 3; but in 1902 it was proved that the correct coefficient is 2·2. The highest actual mean velocities of about 75 m.p.h. had, therefore, been wrongly taken as velocities of over 100 m.p.h.

Maximum Mean Velocities.—The records of a number of important stations in the British Isles show that 75 m.p.h. is the maximum mean wind velocity in Great Britain, which is practically never exceeded.

Maximum Velocity in Gusts.—The variation of the wind velocity in gusts from the mean velocity depends, to a certain extent, upon the exposure of the situation. The maximum gust velocity rarely exceeds 100 m.p.h. in Great Britain.

Wind Velocities in India.—Records show that the wind velocities do not differ very widely in India from those occurring in Great Britain. In India, however, cyclones or tornadoes are likely to occur, which are very local in their maximum effect, perhaps only affecting a section of the country ¼ mile to ½ mile wide and 2 miles to 3 miles long. It is practically impossible to get records of maximum wind velocities in cyclones from the widely-scattered Indian observatories, and the only data available are such inferences as can be drawn from trains blown over. The Government of India has kept careful records of such accidents, and a technical paper on this subject has been published by the Indian Railway Board. The author is of opinion that it would be reasonable to assume a maximum mean wind velocity in India of 90 m.p.h., rising in gusts to 120 m.p.h.

Dynamic Increment Due to Gusts.—It is sometimes stated that a gust should be considered as a suddenly-applied load, and that a dynamic increment should, therefore, be added to the total pressure to allow for its sudden application. Although there may be a considerable rise in wind pressure in a storm in an interval as short as ¼ second, yet it takes several seconds for the wind velocity in gusts to rise from its minimum to its maximum value. Rough calculations show that, if the dynamic increment due to gusts on bridges is to be 100 per cent., the gust must be applied in something less than the following periods: 40-ft. span, $\frac{1}{15}$ second; 100-ft. span, $\frac{1}{10}$ second; 300-ft. span, $\frac{1}{5}$ second. Hence the dynamic increment may be omitted from consideration.

Size of Structure as Affecting Maximum Wind Pressure.—Using the formula $P = 0{\cdot}0031\ V^2$, an average wind velocity of 90 m.p.h. gives a pressure of 25·2 lb. per square foot, while a maximum gust velocity of 120 m.p.h. is equivalent to a pressure of 44·6 lb. per square foot on a small flat plate. Dr. Stanton's experiments show that there is no variation in the pressure due to variation in the size of the surface exposed when the wind is steady. In a variable wind it appears that size has a very considerable effect on pressure. In the experiments made at the Forth Bridge it was ascertained that, on a large plate having an area of 300 sq. ft., the pressure was, on an average, only 66 per cent. of that on a plate 1½ ft. in diameter. Assuming that the maximum pressure in gusts is developed on a small plate, the maximum pressure per square foot on a large square plate approximating to the area of a 40-ft. span, or to that of a railway wagon, might be considered as about 75 per cent. of that on the small square plate. This would give pressures of about 23·3 lb. per square foot under English conditions, and 33·5 lb. per square foot under Indian conditions. As the area of a span increases, the effects of gusts are felt less and less, until on a large square plate, approximating in size to a 1,000-ft. span, the increase of pressure due to gusts would be absolutely negligible. The pressure on such large surfaces is that due to the maximum steady wind velocity. Such wind pressure would be 17·5 lb. per square foot under English conditions and 25·25 lb. per square foot under Indian conditions when considered as a pressure on a flat, square plate.

Effect of Shape.—In the case of rectangular areas or bars the pressure increases with the ratio of length to breadth. If such ratio is 50 to 1 the pressure is 29 per cent. higher than on a square plate of the same total area. Similarly, the pressure per square foot on a lattice is considerably higher than that on a rectangle of similar outside dimensions. The author concludes that, in the case of a small plate girder of about 40-ft. span, the pressure per square foot given in the last section should be increased by about 20 per cent. owing to the elongated shape of the girder, and by another 10 per cent. because of the depressed cup-shape produced by the flanges. For a lattice span of 600 ft. or over, the increase should be about 35 per cent. above the pressure developed in a steady wind on a flat plate. A reasonable assumption to meet Indian conditions would be to allow pressures on unloaded spans ranging from 44 lb. per square foot for a 40-ft. span to 34 lb. for a 600-ft. span and over. Corresponding figures for English practice are 30 lb. to 24 lb. per square foot.

Wind Pressures on Loaded Spans.—The effect of the train surface in increasing the area exposed to the wind and the smaller resistance offered by a body like a train as compared with that offered by a surface like a bridge are considered, with the result that the author recommends for loaded bridges in India an allowance for wind pressure ranging from 36 lb. to 31 lb. per square foot, the corresponding figures in England being 25 lb. to 22 lb.

The question of the shielding effect of the windward girder is discussed, and certain recommendations are made. The method of calculating wind stresses in bridges and the approximate range of stress due to the wind are considered, and the great importance of the overturning action of the wind on both the bridge and on the train is demonstrated. In certain cases, the stress due to the overturning action is eight times as great as the stress due to the horizontal component of the wind. Cases of a high range of wind stress in certain types of bridges are cited, and it is shown that, in a 150-ft. through span, the wind stress may increase the combined dead, live, and impact stresses by 30 per cent. The great importance of considering wind in the design of narrow-gauge spans is considered. In an 80-ft. plate-girder deck span the wind stress may amount to 44 per cent. of the total combined dead, live and impact stresses.

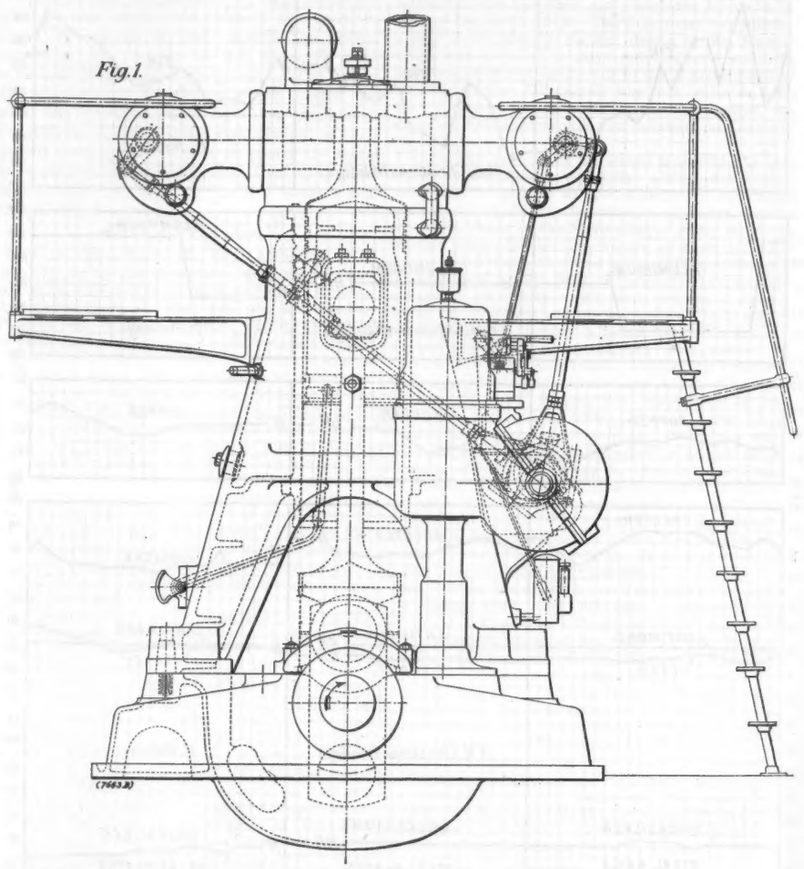
* Abstract of a paper to be read at the Institution of Civil Engineers, on Tuesday, February 6, 1923.

COLD-STARTING SOLID-INJECTION OIL ENGINE.

CONSTRUCTED BY MESSRS. RUSTON AND HORNSBY, LIMITED, ENGINEERS, LINCOLN.

(For Description see opposite Page.)

Fig. 1.



DREDGING PLANT.—Mr. George Anderson, A.M.I.N.A., 9, Fenchurch-avenue, E.C. 3, has issued a pamphlet giving particulars of dredging and floating harbour plant for sale.

THE GOLD MEDALS AND PREMIUMS OF THE INSTITUTION OF NAVAL ARCHITECTS.—The Council of the Institution of Naval Architects have awarded the gold medal for 1922 to Mr. J. L. Kent, of the William Froude Experimental Tank, for his paper "Experiments on Mercantile Ship Models in Waves," and premiums have been awarded to Mr. E. Leslie Champness, M.B.E., M.Sc., for his paper "Longitudinal Strength of Cargo Vessels and its Variation with Fullness of Form," and Major L. Fea, of the Royal Italian Navy, for his paper "Some of the Consequences of the Washington Conference with Regard to Naval Construction." The above awards will be presented on March 21, at the opening of the annual meetings of the Institution, which will be held at the Royal United Service Institution, Whitehall.

VERTICAL COLD-STARTING SOLID-INJECTION OIL ENGINES.

CONSTRUCTED BY MESSRS. RUSTON AND HORNSBY, LIMITED, ENGINEERS, LINCOLN.

Fig. 2.

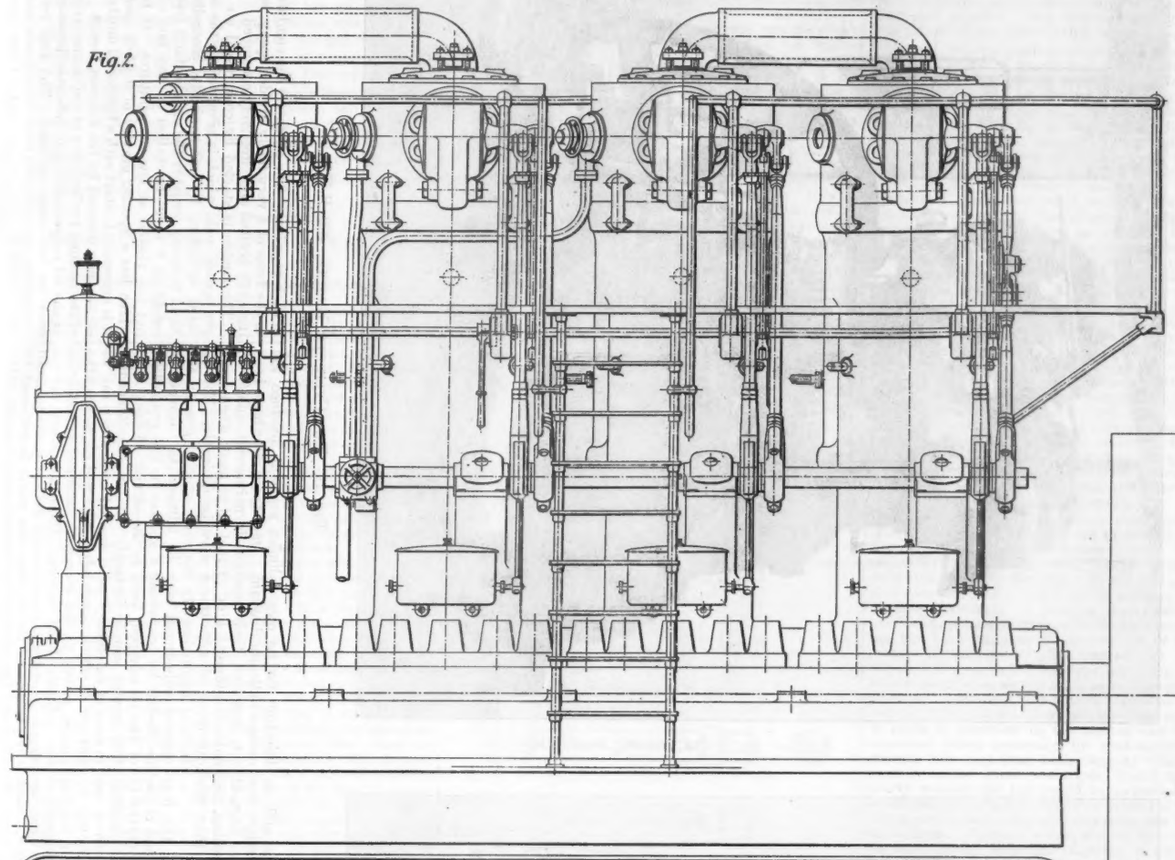
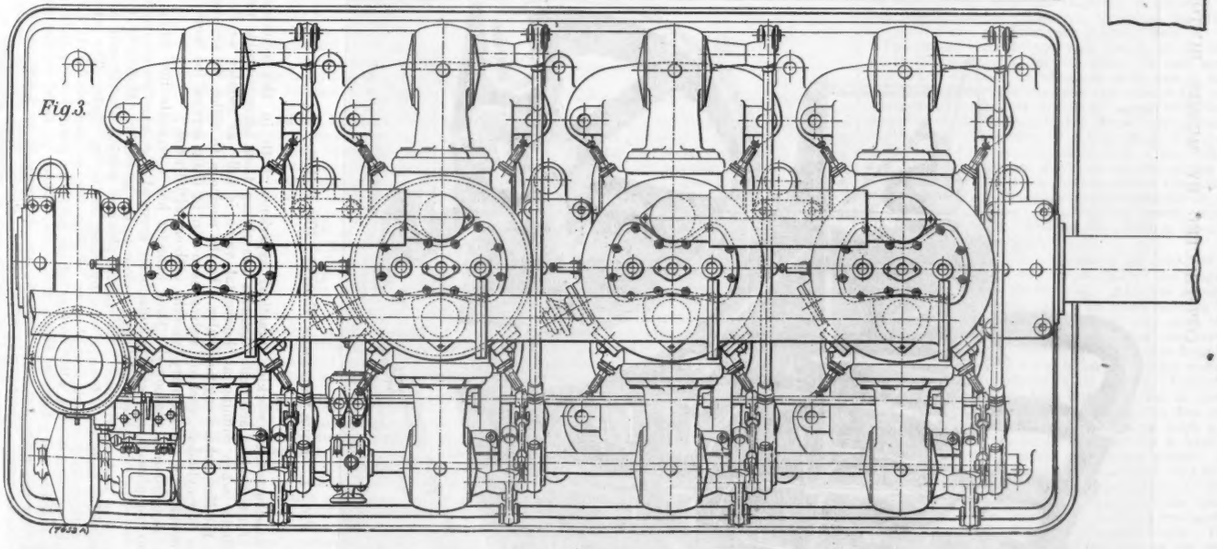


Fig. 3.



IN the development of the modern heavy-oil engine, which will start from the cold condition and will work efficiently on fuels of the cheapest and crudest nature, Messrs. Ruston and Hornsby, Limited, of Lincoln, have taken a prominent part. Until recently, however, the firm confined itself to the manufacture of engines of the horizontal type, which it has supplied in large numbers to all parts of the world. As a result of the experience gained, and in order to meet the conditions for which vertical engines are more suitable than those of the horizontal type, Messrs. Ruston and Hornsby, Limited, have now developed a series of vertical engines retaining the special characteristics which rendered their horizontal design so successful. One of these, designed for a continuous working load of 380 b.h.p. at 250 r.p.m. but capable of carrying an overload of 20 per cent., has recently been supplied to the Maidenhead Corporation Electricity Works, to the order of Mr. C. O. Milton, the electrical engineer of the borough. This engine is direct-coupled to a continuous-current generator of 250 kw., and as the station also contains a Diesel engine set of very similar capacity, there is the possibility of making a very practical comparison between the performance of the two types. In the matter of fuel consumption we understand that this has already been done, with the result that while both engines show substantially the same economy at full load, at lower loads the advantage lies with the Ruston engine It is only fair to remark that the Diesel engine is several years old, but nevertheless the higher efficiency of the new engine at low loads is certainly to be expected on account of the absence of the high-pressure compressor for the supply of injection air.

Drawings of the new Ruston engine, as installed at Maidenhead, are given in Figs. 1 to 3, on this and the opposite pages, and its general appearance is shown by Fig. 4, on page 154. Engines of the same type are built in sizes ranging from 75 b.h.p. to 150 b.h.p. per cylinder. For smaller powers a slightly modified

VERTICAL COLD-STARTING SOLID-INJECTION OIL ENGINES.

CONSTRUCTED BY MESSRS. RUSTON AND HORNSBY, LIMITED, ENGINEERS, LINCOLN.

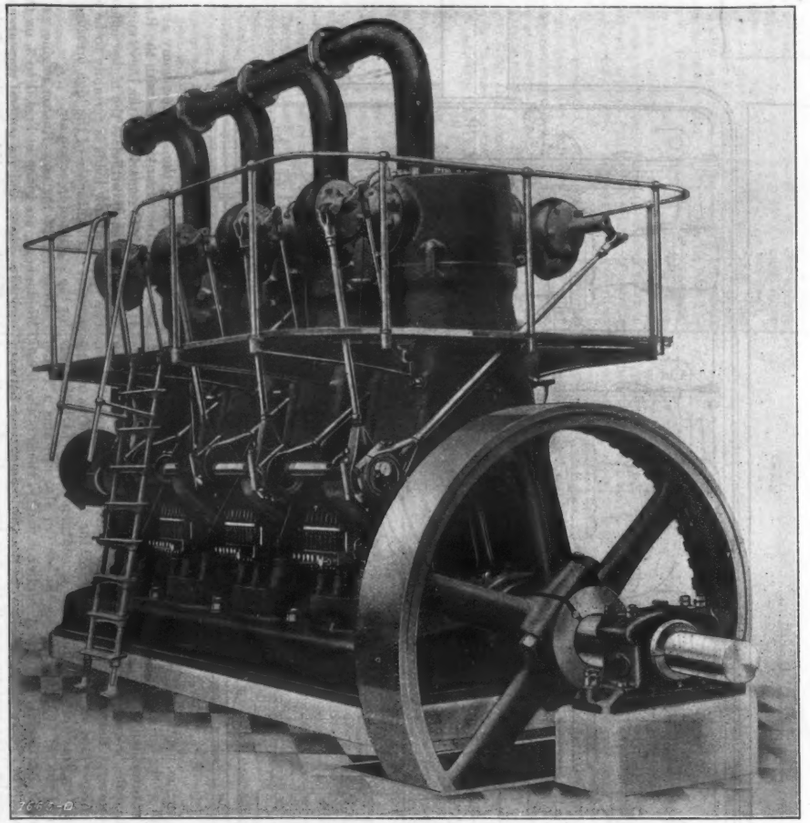


FIG. 4. FOUR-CYLINDER ENGINE, 400 B.H.P.

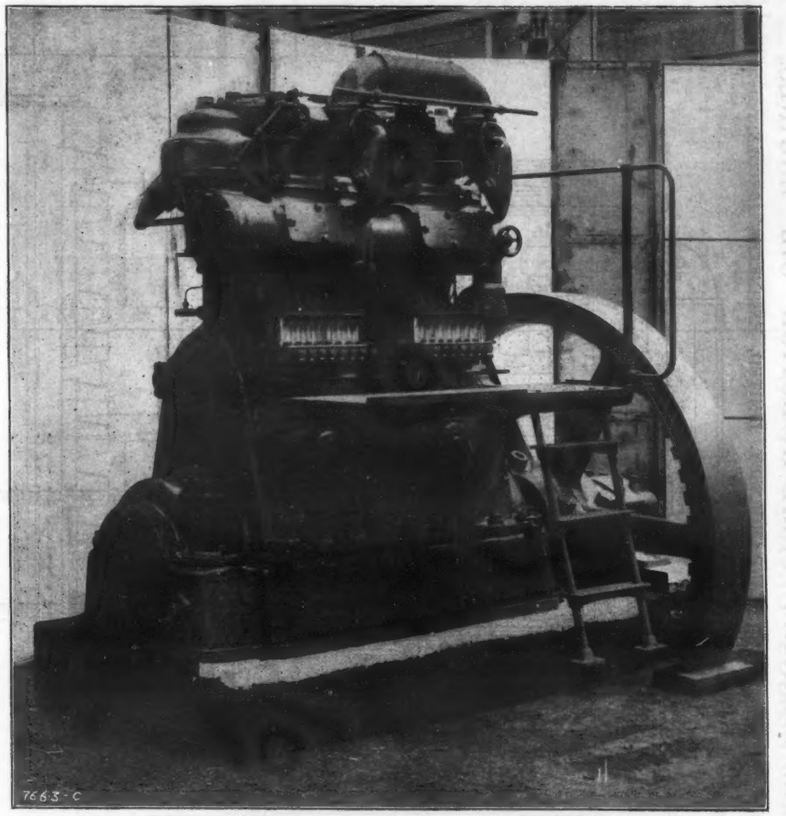


FIG. 5. TWO-CYLINDER ENGINE, 100 B.H.P.

design, illustrated in Fig. 5, is constructed, the working parts being totally enclosed. Such engines are built to develop 50 b.h.p. per cylinder when running at 300 r.p.m. Referring again to the Maidenhead engine, shown in Figs. 1 to 4, this has four cylinders, each of 16-in. bore by 22-in. stroke, working on the ordinary four-stroke cycle. The fuel is injected into the combustion space by a pump, no compressed air being needed, the pressure in the cylinder being high enough to ensure instantaneous ignition and combustion. The general design of the engine will be understood from the illustrations. The inlet and exhaust valves are operated by separate eccentrics in conjunction with rolling levers, the latter being cased in and lubricated by oil under pressure. The valves are horizontal, and are fitted in cages within the cylinder heads. There was at one time a prejudice against horizontal valves, but practical experience both in this country and in America has shown that, given suitable design, the horizontal valve is fully as reliable as the vertical valve. In the engine with which we are dealing, the valves have run in daily service for more than two months without withdrawal.

Each cylinder has a separate fuel pump, the four pumps being grouped close together at one end of the engine close to the governor. Motion is imparted to the pump plungers during the inward or working stroke by cams on the lay shaft. The return of the plungers during the suction stroke is effected by springs which keep the pump lever rollers in contact with the cams. There is thus neither reversal of pressure, nor clearance to be taken up, so that the pumps operate quietly and without chatter. Each fuel pump cam is adjusted separately to time the injection for its own cylinder so as to produce the correct indicator diagram. Once these cams have been set, however, their position is permanent unless an entirely different kind of fuel oil is used, when some difference of adjustment may be desirable. For all fuels of approximately the same specific gravity the original adjustment may be adhered to. Governing is effected by by-passing a greater or less proportion of the oil pumped, back to the service oil tank. All four pumps can be instantly cut out simultaneously in case of emergency, or if desired each pump can be put out of action separately. The fuel oil leaving the pumps passes to the atomisers arranged centrally in the cylinder head covers. These atomisers are of simple construction and cannot deliver a charge until the pressure of the oil from the pump is sufficient to overcome the resistance of a spring-loaded needle valve in each atomiser. The oil enters the combustion space in the form of a very finely divided spray, so that it is instantly ignited and effectively consumed.

The engine is started by compressed air at 250 lb. per square inch, which is admitted to the second and third cylinders by mechanically controlled valves. Even in frosty weather the engine starts from the cold condition without hesitation on any fuel oil which is not too viscous at low temperatures. If furnace oil, which has a specific gravity of 0·95 is used for fuel, it is necessary to start with a lighter oil until the heavier oil becomes warmed by the exhaust heater. A feature of the running performance of the engine is the evenness of the oil consumption per indicated horse-power hour over its full range of load. The fuel consumption during the official works tests on a dynamometer brake was 0·413 lb. of oil per brake horse-power hour.

Subsequent tests at Maidenhead, when the engine was driving its own generator, showed a consumption of 0·613 lb. per kilowatt-hour at a load of 250 kw.

It is almost unnecessary to state that ignition of the charge does not depend upon any heated surface, or that no water injection is required at any load. In spite of these facts the ratio of the initial pressure on the power stroke to the compression pressure is considerably less than in the case of the hot-bulb, or so-called semi-Diesel engine. The elimination of the necessity for high-pressure air for fuel injection, and the fact that there are no running adjustments whatever to be made, are considerations which tell greatly in favour of the type of engine described, especially in places where skilled attention and maintenance is difficult to provide. Engines of the type in question are built for all power purposes including the driving of alternators in parallel.

MACHINING AND LAPPING VERY DEEP HOLES.*

By Major JOHN B. ROSE,† Fort Leavenworth, Kan.

(*Concluded from page* 92.)

Lapping.—A proper appreciation of the art of producing these holes with mirror-like surface cannot be obtained without some consideration of the steel characteristics. The ordinary run of steel, such, for example, as S.A.E. No. 1,035, will, after rough-machining and reduction to a cross-section suitable to take treatment, take a fine finish in a bored hole from reamer, broach, or grinding wheel. Whether it can be lapped and polished free from scratches is altogether another matter, as this depends upon its condition.

If a mirror-like finish free from scratches is required at the end, it is clear we have a different problem. The utmost cleanness and homogeneity is necessary. Slag inclusions or oxides will show up in the final operations and the entire work be lost. Machining quality must be good, as a small tear may be disastrous.

The first problem thus appears in the selection of the steel. Ordnance gun steel is clean and quite machinable, but unless very carefully made it is not clean enough to give a mirror finish in lapping. It is probable that our steel makers during the war were somewhat sceptical as to the necessity of delivering a perfectly clean, soft steel. We know, however, that excellent and satisfactory steel can be produced by American processes when the requirements are understood and fully accepted.

Since for the lapping operation clean steel is fundamental, it is necessary to go into this at more length. Slag and other impurities are practically independent of the chemical composition of steels which may be employed, and the amount of inclusions will depend upon furnace and pit practice. It is not so much a question of the kind of steel as it is of the care in manufacture. The electric furnace undoubtedly gives a very superior clean steel, but this is due largely to proper care and it cannot be concluded that the open-hearth will not yield a steel equally clean. In fact, we know it can, and it remains for the steel buyer to decide which process is more likely to give him a steel free from inclusions. If the steel makers understand the requirements, either kind can meet them if the necessary precautions are taken, but in the open-hearth greater care must be exercised and the electric furnace is probably surer.

Both the Watertown and Rock Island Arsenals have had extended experience in lapping, and have each reached definite conclusions. The Rock Island Arsenal favours a nickel alloy steel made in the electric furnace, and very excellent results have been obtained with a steel of the following percentage composition :—

Carbon	0·30 to 0·40
Manganese	0·50 to 0·80
Sulphur	less than 0·045
Phosphorus	less than 0·040
Silicon	0·15 to 0·35
Nickel	3·25 to 3·75

The steel to be free from all slag inclusions, flakes or any lack of homogeneity, and heat-treated to give elastic limit of 65,000 lb. per square inch. It was found that this steel worked freely under the stone and took a high polish without the appearance of scratches or pockets due to soft spots.

It may be noted here that the initial cost of the steel must not be given too much weight, for unsuitable steel is in the end very expensive, due to eventual rejections. Such rejections were a serious burden in our war manufacture. Too often we blamed the laps for scratches, when in reality the steel itself was the source of trouble, or the entrance of foreign particles of dust and steel.

The Watertown Arsenal feels that the acid open-hearth will give steel as free from inclusions as the electric furnace with careful control of melting practice and proper top and bottom discard.

It is not possible in the limits of this paper to discuss all sides of the steel question, nor is it desirable. But we can draw a few conclusions from our experience to date. To secure the best results we are fairly sure that :

(*a*) The steel must be produced by the most careful furnace and pit practice.

(*b*) It must be thoroughly deoxidised, free from slag and inclusions which produce scratches or pit marks in lapping.

(*c*) The chemical composition may be such as to yield physical qualities desired under the heat treatment permissible.

(*d*) The heat treatment must be such as to produce great uniformity in hardness and the desired physical properties.

A few words regarding heat treatment are necessary. In dealing with forgings of large cross-section it is evident that the desired qualities can best be secured after rough-machining and boring. During the war it was necessary to heat-treat before rough-machining, due to the lack of machine shops, with heat-treating facilities suitably located or available, to conditions of transportation, distribution of work, and various other influences. Basically it is much better to heat after reduction of the forging to nearly its final shape.

After finish-reaming, finish-planing and milling certain surfaces, the piece goes to the lapping machine. It is not desired to present this machine as ideal ; in fact, it has numerous defects. First of all, horizontal lapping of cylinders is believed to be fundamentally wrong, since the gravity forces are constantly changing, as will be shown. In addition, the machines used were noisy and the reciprocating weights unnecessarily large. It can only be said that vertical lapping required too much head room to permit it, and that these machines were the best obtainable at the time.

When the machine is rigged for lapping, the piece is held stationary in its fixture and the upper bar with the lap is reciprocated by means of the travelling carriage as in a shaper. The lap cuts on both strokes and is rotated 30 deg. at each reversal. As the stone is about

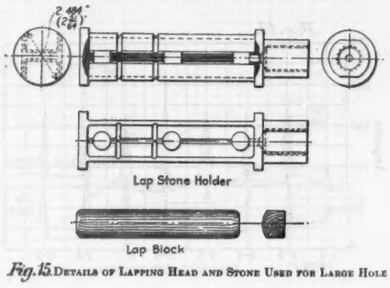


Fig. 15. DETAILS OF LAPPING HEAD AND STONE USED FOR LARGE HOLE

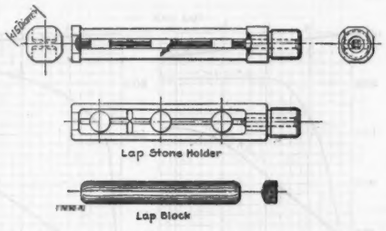


Fig. 16. DETAILS OF LAPPING HEAD AND STONE USED FOR SMALL HOLE

60 deg. wide it overlaps the preceding stroke and no lines are left. The stroke is adjustable in length and the carriage may be set to lap any section of the hole desired. The piece is slid on the fixture, the edges D and E, Fig. 7, resting against the vertical guiding surfaces of the fixture, and the surfaces F and H supporting the weight and fixing the holes in proper vertical relation to the centre line of the lap bar. There is a clearance of about 0·01 in. between the guides of the work and the vertical sides of the fixture, so it is manifest the hole is not aligned very accurately with the centre line of the lap bar. It is evident that the hole thus partly guides the lap. In view of the inevitable flexing of the long bar it is of no use to set up the piece with rigid accuracy, and the lap is therefore allowed to float with comparative freedom in the hole, the more so the better.

We must therefore say that the object of lapping is to improve the accuracy and finish of the reamed hole ; hence it is obvious that the more accurate the reaming and the better the finish, the less there will be to lap. Working in good steel, 0·004 in. on diameter is enough to allow removal of reamer marks and leave a polished finish, but ordinarily more than this was left for lapping.

Figs. 15 and 16 show details of the lapping heads and stones used. (In the figures wood lap blocks are shown.) It was originally intended that the stones should be forced out by radial coiled springs, thus securing a uniform pressure in the hole, but this was abandoned for the reason that a uniform pressure does not lap the hole uniformly when the sections are of unequal hardness, and if there are small and large sections these remain respectively small and large. The stones were therefore assembled in the head and shims placed under them until they entered the hole snugly. Shims were also added as the stones wore down. By this method the pressure is least on low spots, or if a spot is soft and wears faster, the pressure is automatically reduced. It was proposed to use heads with a taper adjustment, but these were never actually employed.

After finish-reaming the holes were star-gauged to 0·0001 in. and this record went to the lapping machine By experience it was determined that in a certain time the stones would remove a given amount of material, and it was possible for the gang boss to examine the record of gauging and direct so many minutes' lapping on each piece, based on the amount of metal to be removed. A general rule was not altogether reliable for the final stages of lapping as there was not sufficient uniformity in the steel or in pressure of stones ; and it was customary for the gang boss to determine the lapping constant for each piece after a preliminary lapping of about 20 minutes and star gauging. This constant was then used to set the times required for further lapping required.

It was seldom possible to obtain a round hole with a variation in size of less than 0·0005 in. without resorting to spot lapping. Means were provided for frequent star gauging upon call of the gang boss, and if the record showed small or large sections the stroke was adjusted by the gang boss to spot-lap the small diameter. In this way the total variation measured on diameters would be made 0·0005 in. or less. Ordinarily this required about 8 hours or more per piece.

Due to frequent oversize reaming to remove defects or reamer marks the pieces went to the lap with holes varying in size and the amount of lapping therefore varied, the practice being to continue lapping until a regular hole with good finish was obtained.

As already indicated the steel used was not of a suitably uniform character to permit a standardised shop practice with resulting economy in time, and for this reason the question of steel has been emphasised.

The important characteristic of the holes was roundness, and this was obtained. They were not accurately straight in the sense of a straight edge. Accurate records have unfortunately not been taken on enough finished recuperators to permit a statement of the variation in straightness. Isolated measurements indicate some of the holes may have been bowed as much as 0·035 in. These were very bad ones and very unusual. An average good hole was straight within an error of 0·005 in. Of course this is far from straight in comparison with a straight edge, but for a small hole 5 ft. long the accuracy is good for quantity production and it probably can be improved under standardised conditions.

The lapping head of type shown gave acceptable results, but it is felt that it can be improved. Four stones instead of two might give better results. The method of adjusting the stone is slow. There should be a quick adjustment to suit the hole. In the end additional vent holes were drilled in the head to allow more free access of oil to the stones. A mixture of one-half kerosene and one-half pure lard oil was run to the lap through the hollow lap bar. An increase in the amount of kerosene gave greater cutting speed when desired. It is essential to circulate the oil through a filter and keep it very clean. It is evident that as the lap passes through the hole the pressure on the top and bottom varies as the overhung weight of the lap and bar varies. This actually tended to cause a variation in the size of the hole, but was corrected when necessary by spot-lapping. A nicely reamed hole requiring little lapping could be finished quickly before these variations would appear, but if poorly reamed the lap would in extended use produce variations in diameter. Also in extended lapping there is a tendency to wear spots unequally, due to a difference in hardness. In other words, the lap does not straighten the hole except when spot-lapping is resorted to, and this should not be necessary ; therefore the steel must be uniform and good reaming insisted upon.

The pressure on the top and bottom is not the same nor is it the same as on the sides. It may seem that this would produce an elliptical hole, but it does not, due to the fact that the diameter across the stones is enlarged by shims as the hole wears and the small diameter of the hole gets the most cutting each time this is done. The effect of this pressure due to weight is, however, to lower the centre line of the entire hole, and it is also true that if the centre line of the reamed hole is not lined up with the lap stroke, the axis of the hole will be shifted. This again emphasises the importance of minimum lapping. The lapping speed was about 275 ft. per minute. The machine had a lower speed, but this was seldom used.

Lapping Stones.—The selection of suitable stones led to many weeks of experiment before the proper grain and grade could be determined. Abrasive stones of all the leading types were tried, with many peculiar results. As a very fine finish was sought, it may seem that the finest grain would be suitable. This was not true. A stone of grain 220 (the finest above the flour) would, for example, not give a finish, but in certain cases would stop cutting and burnish a streak. Carborundum 180G4 was found the best cutting stone in nearly all cases. This stone cut clean and smooth, and in many cases the finish lap or polish was given with it alone. Again, one stone would be replaced by a hard maple block and the combination gave a fine polish. A gang boss was in charge of each six machines and this man learned by experience, from the appearance of the hole, which combination would most likely give the best finish.

When 180G4 would not finish, a FFG4 was used either alone or in combination with a maple block. The two maple blocks were never used together as the tendency was to burnish in streaks and cutting action was necessary up to the end. It is necessary to keep the stones ground flat on the under side which lies against the shim, and to the correct radius on the curve. This was done by rubbing them on cast-iron lapping blocks, flat or ground to radius, with kerosene and carborundum grit. This was done whenever a stone showed signs of glazing or cutting in spots. It cannot be assumed that stones in the same lot and grade cut just alike, and although presumably the same, differences in cutting were frequently noted. In this very fine work a variation in the hardness or the least irregularity in grain is quickly revealed by the appearance of the cut.

A broken stone usually ruined the job, and this was the source of some loss. A wire centre was used with

* Paper contributed by the Ordnance Division and read at the Annual meeting, New York, December 4 to 7, 1922, of the American Society of Mechanical Engineers. Abridged.

† U. S. Army. Mem.Am.Soc.M.E.

by oil under pressure. The valves are horizontal, and are fitted in cages within the cylinder heads. There was at one time a prejudice against horizontal valves, but pressure, nor clearance to be taken up, so that the pumps operate quietly and without chatter. Each fuel pump cam is adjusted separately to time the

success, but the stone generally used was not so made. The edges and corners of the stones must be well rounded to prevent chipping or scratching. It is well known that the appearance of a clean, bright tube—for example, a gun barrel—is deceptive. The repeated reflection of light gives an exaggerated polish. The holes in this case gave the illusion of great brilliance, which was of course increased by bright artificial light or a bright sun. It is only by experience that one can form an idea of the actual condition of a hole. To fix a standard, all holes should be examined under the same kind of light. This is preferably diffused daylight or diffused light from a ground bulb. The latter is more nearly constant. To examine the hole still more closely, a magnifying mirror set at 45 deg. and mounted so it can be inserted to any point desired will give a very good idea of the interior. This should always be used in case of doubt or until the eye has learned to judge correctly.

In closing, it should be stated that the character of the steel on which these observations are all based must be noted, as a change in this alters other conditions. The forgings ran on the average: 0·50 carbon, 0·65 manganese, and 0·30 silicon, with very low phosphorus and sulphur. They were heat-treated to 50,000 lb. elastic limit and about 100,000 lb. tensile strength.

VARIABLE-SPEED ALTERNATING-CURRENT MOTORS WITHOUT COMMUTATORS.*

By F. CREEDY, Associate Member.

(*Concluded from page* 91.)

CHARACTERISTICS OF THE EQUIPMENT.

We now come to the description of the characteristics of machines of this type which are rendered available by the system of control just described. As has already been pointed out, squirrel-cage motors of the multi-speed type can find a very much greater field of utility than when used on a single-speed only, since the chief drawback is almost completely overcome in the multi-speed form. This advantage, of course, relates to the starting.

Consider, for instance, a two-pole and a four-pole motor, both having the same air-gap density. In the former there will be only two conductors in series, each lying in the middle of the pole-face, and the four-pole motor will have four such conductors. If, therefore, we send the same current through the four conductors as through the two conductors, we shall obtain twice as much torque in the four-pole machine as in the two-pole machine, or, alternatively, for the same torque the four-pole motor will require only half as much current; hence, if we can arrange a motor so that it starts on four poles and runs on two poles, to obtain a given starting torque it will take only half the starting current that it would require if it started on two poles. This is the origin of the very greatly improved performance of the squirrel-cage motor when used as a multi-speed machine. In squirrel-cage motors having a speed-range of 2 to 1, or more, it is always possible to obtain full-load starting torque with not more than twice full-load current. All machines of whatever size, having the same speed-range are capable of this ratio of starting torque to starting current, but if switched straight on to the line larger machines frequently take much greater current and give correspondingly greater torques. In most cases, therefore, the use of an auto-transformer is necessary with large machines. This may be seen from Fig. 16, in which is shown starting torque plotted against starting current for a four- six- and eight-pole motor built by Messrs. F. and A. Parkinson, Limited. It will be seen that with the eight-pole connection the machine gives 1·7 times full-load torque with twice full-load current. With a six-pole connection it gives 2·4 times full-load torque with 3·6 times full-load current. With a four-pole connection it gives three times full-load torque with 8·6 times full-load current.

Another point frequently arising with multi-speed squirrel-cage motors relates to the current-rush on changing speed and the rate of acceleration from one speed to the next. Both these factors are under exact control by the use, in series with the motor, of primary resistance, which, of course, has the effect of reducing the voltage during the change of speed.

Returning to Fig. 15 (page 90 ante), in order to use this method of regulating the rate of acceleration between speeds, there is fitted on the panel by the side of those shown a third contactor which opens when they open, and which closes, due to the action of a dashpot, a few seconds after they close. This third contactor, when closed, bridges three resistances each placed in series with one of the lines; hence, directly the contactor opens, these resistances are placed in circuit, being adjusted to produce any desired rate of acceleration. They remain in series with the line during the operation of changing speeds, and are cut out when this operation has been completed.

In Fig. 17 is shown the current-surges produced in changing speed in a squirrel-cage motor arranged for all numbers of poles between 8 and 16, both with and without (dotted curves) a similar device. Substituting an auto-transformer for the resistance, it will be seen that by its use the maximum current surge is reduced to about one-half.

In a motor having a wide speed-range, the lowest speed-steps are very small and there is seldom any need for such a device. It is on high speeds, however, that it is needed. The figure illustrates the marked reduction in the current surge on these higher speeds (shown towards the right of the figure), the device of course, being adjusted to suit this case.

This method of starting and changing speed can be employed in motors up to several hundred horse-power, and renders the squirrel-cage motor adaptable to a vast variety of purposes for which it has never been found possible to use it before. A further extension of its field may be obtained by the use of centrifugal clutches, now coming into such general use, which may be arranged to operate at the lowest speed of the motor, the speed-change from this point being arranged in the manner just described.

To sum up, the sequence of operations to change speed in the case of a squirrel-cage motor, for instance, would be as follows:—

(1) The first movement of the controller-handle causes the contactor to open, thereby cutting off the supply from the installation and rendering it "dead."

(2) A further movement of the controller-handle opens the "switch-units" and re-closes them in the correct combination to suit the next speed and, as the supply is cut off meanwhile, the change takes place without any sparking.

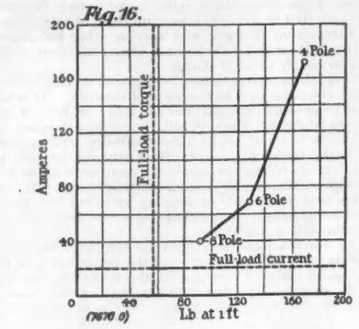
(3) When the controller-handle has been moved to the notch corresponding to the speed desired, the contactor closes again and the circuit is re-established, the whole operation of changing speed taking approximately two or three seconds and being accomplished by one movement of the controller-handle. In Fig. 18 is shown a series of circle diagrams for such a multi-speed motor operating on all numbers of poles from 6 to 16 and absorbing the same magnetising current in all cases. These diagrams assume that the leakage co-efficient is proportional to the number of poles, thus being twice as great in a 12-pole machine as in a 6-pole one. It will be shown below that this assumption is very nearly fulfilled in this type of machine.

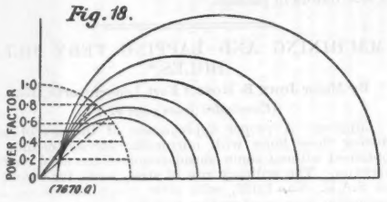
This figure shows clearly the cause of the very great economy in starting current which is found in practice and was illustrated in Fig. 16. It will be seen that with 16 poles the motor takes about one-third of the starting current required with a 6-pole connection. Since the motor gives the same torque at all speeds, the ordinates to each circle represent the torque to a scale such that the torque represented by 1 mm. on the diagram is proportional to the number of poles. Hence, in spite of the small current consumption, the motor can yield a powerful starting torque at the lowest speed.

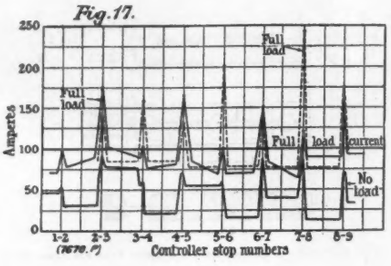
Slip-Ring Motors.—It is possible to design a rotor winding for a machine having any number of speeds which shall give genuine slip-ring control up to one of these speeds, for instance, the top speed, and operate as a short-circuited secondary winding on all other speeds. One way of effecting this result is by using such a winding as is shown in Fig. 6 (page 88 ante), but permanently connected so as to be capable of direct connection to the line. This connection is shown in Fig. 19 and it will be seen that, as so connected, the winding requires no more than three terminals and can therefore be connected to the usual number of slip-rings.

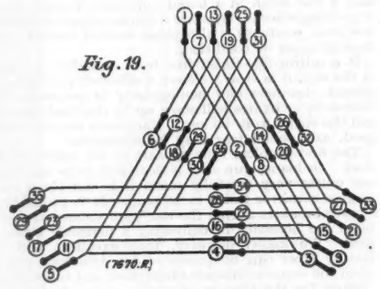
On all other numbers of poles than six, however, the winding would require more than three terminals to enable it to be connected to any outside circuit, and if these terminals are short-circuited the winding is also internally short-circuited. Hence, the secondary currents which on 6-pole operation flow through the slip-rings, on any other number of poles flow through the internal circuits of the winding and do not pass through the slip-rings at all.

By means of this construction a motor is produced which can be arranged to be accelerated, by means of









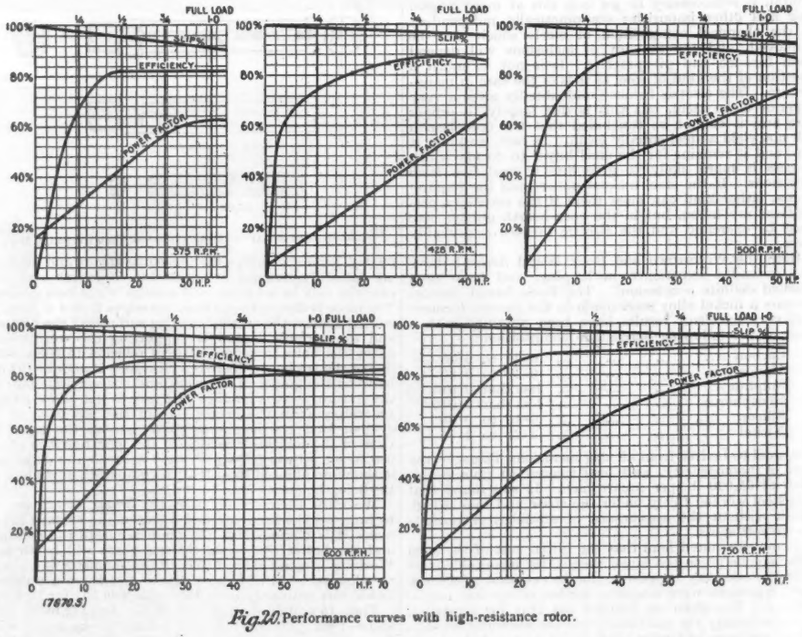


Fig. 20. Performance curves with high-resistance rotor.

* Paper read before the Institution of Electrical Engineers on January 4, 1923.

an ordinary resistance connected across its three slip-rings, from standstill to any one of six speeds, starting, if desired, from 2 to 2¼ times full-load torque. On reaching the speed at which it is desired to run, a movement of the controller-handle changes the number of poles of the motor to the desired value, when the currents in the rotor winding are automatically diverted from the slip-rings and continue to flow in closed circuits in the winding.

The operation of starting the slip-ring motor on any other than the top speed is therefore as follows :—

(1) Set the controller to the starting position which will produce in the motor a number of poles corresponding to the top speed.

(2) Gradually close the starting rheostat, when the motor will speed up.

(3) When the motor has reached the speed desired, which will of course be less than top speed, move the controller from the starting position to the running position corresponding to the speed at which it is running. This will have the effect of changing the number of poles to that corresponding to the controller notch employed, when the starter is automatically cut out as already described and the motor continues to run with its rotor short-circuited.

(4) The starter may now be open-circuited at leisure.

A tachometer may be provided in order to enable the operator to know the proper moment to change from starting to running position.

In Figs. 20 and 21 are shown some curves of efficiency and power factor of a 70-h.p. motor arranged to give all numbers of poles from 8 to 16.

Fig. 20 shows efficiency, power factor and slip curves for the 70-h.p. motor referred to above, arranged to give all numbers of poles from 8 to 16. These curves correspond to the results obtained when fitted with a high-resistance rotor adapted to give the powerful torque required in connection with this motor.

Fig. 21 shows corresponding curves for the same machine when fitted with a normal low-resistance rotor commonly used with squirrel-cage machines. Comparing these two sets of curves, a result will be noticed which at first appears rather strange, namely, that the efficiencies of the machine with a high-resistance rotor and with a low-resistance rotor are not very different for the same speed, while the power factor of the machine with high-resistance rotor is a good deal less than that of the machine when fitted with low-resistance rotor.

This is due to a method which can be employed in the induction motor to enable a high-resistance rotor to be employed without loss of overall efficiency. The torque of the motor is, of course, proportional to the product of ampere-conductors by flux density. If, therefore, we compare two motors having, say, flux densities in the ratio of 1·5 to 1, then in order to give the same torque they will require a number of rotor ampere conductors in the ratio of 1 to 1·5, the machine having the stronger flux density requiring only two-thirds of the current in the rotor bars required by that having the smaller flux density. Two-thirds of the rotor current means of course four-ninths, or less than half, of the rotor I^2R loss and, consequently, if we desire the resistance loss to be the same in both cases, the machine with the stronger flux density may have 2¼ times the rotor resistance of that with the weaker flux density.

This method was adapted in the motor illustrated in the above figures, which, by means of tappings on the transformer, was adapted to operate with either a strong or a weak flux. The strong flux used with the high-resistance rotor involves, of course, low power factor, and this is the explanation of the nature of the curves shown. By using stalloy steel punchings the iron loss was reduced to such a small proportion of the whole that the increased iron loss due to the stronger flux produced only a negligible effect on the efficiency.

Thus, by this process the squirrel-cage motor can be adapted to give any desired starting torque, without loss of efficiency, wherever we are prepared to sacrifice power factor to obtain this result, or to use additional power factor compensation devices such as condensers.

Power Factor and Efficiency.—Referring to the curves given above, it may be seen that the characteristics of the machine as regards power factor and efficiency are, broadly speaking, as follows :—

The efficiency remains very nearly the same at all speeds, though there is a slight reduction at reduced speeds, due, broadly, to the fact that the losses remain approximately constant at all speeds, while the output, of course, falls off in proportion to the speed. In the larger sizes, this reduction in efficiency will seldom exceed 5 per cent. The efficiency at top speed is, of course, practically the same as in a standard motor. The power factor also varies, as we change speed, to a somewhat greater degree than the efficiency, this variation being due, broadly speaking again, to the fact that the magnetising current remains the same at all speeds while the true power input falls off proportionately to the reduction of speed. Again, in the larger sizes this variation will seldom exceed 10 per cent.

The only thing which needs to be borne in mind from the power supply point of view is that these machines absorb a constant amount of wattless current at all speeds, and that this amount is not greater than that absorbed by a standard machine having the same rating. Perhaps it may serve to make the matter clearer if we compare the equipment with a standard motor driving through a gear-box, a load which requires constant torque at all speeds. At top speed the motor is fully loaded and operates with its best power factor and efficiency. As the speed and the load are reduced by changing gear, the output of the motor falls off and with it the power factor and efficiency to some extent. To almost exactly the same extent do the power factor and efficiency of the equipment described fall off when the load is reduced; in fact, the controller described above may be regarded as an electrical method of changing gear.

Reference has been made above to the fact that the leakage coefficient of these machines is practically proportional to the number of poles, and in Fig. 22 are shown some curves of leakage coefficients plotted against the number of poles. These curves illustrate this feature. Such curves, it is believed, will be of considerable interest to designers, and clearly could not be obtained from any other type of motor except one retaining an absolutely identical winding on all numbers of poles. Comparisons have frequently been made between motors having different numbers of poles, but this, of course, is not at all the same thing as in the case of a single multi-speed motor.

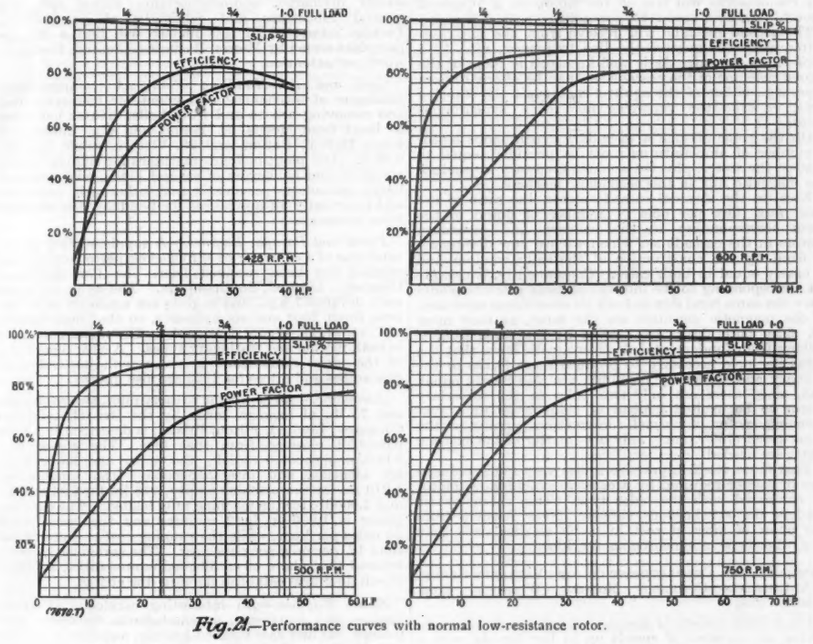


Fig. 21.—Performance curves with normal low-resistance rotor.

PART II.

THE CASCADE MOTOR.

As previously pointed out, a second line of progress in the development of the induction motor leads in the direction of the internal cascade machine, as originally invented and developed by Mr. L. J. Hunt, but which has recently undergone very great further developments which have adapted it to a very much larger field.* The cascade machine has been described before the Institution several times in recent years and therefore I need only describe its principles very briefly, laying more stress on the different practical forms which it assumes and on the functions which it is capable of performing in the general system of electric power supply.

We may first of all briefly recall the general principles of a cascade operation. One may first consider two machines mechanically coupled together, in which the slip-rings of the first are connected to the stator winding of the second. The second machine is assumed to be wound for two poles and the first for six, and the combination will run at 750 r.p.m. on a 50-period circuit, viz., at a speed corresponding to (6 + 2) poles.

One of the marked advantages of a cascade set is that it is possible to obtain not only two efficient speeds but also resistance control from standstill to the lower speed and, in addition, resistance control from the lower speed to the top speed.

If the rotor of the second machine is fitted with slip-rings, then, if the first machine is connected to the line and the slip-rings of the second machine are gradually short-circuited through a resistance, the machine will start and rise gradually in speed, being under complete control by means of the rheostat, to the lower of its two efficient speeds, which it reaches when the slip-rings are completely short-circuited. If we now connect a similar resistance across the slip-rings of the first machine, then, on gradually short-circuiting them, the machine will rise from its lower efficient speed, say 750 r.p.m., to the higher, 1,000 r.p.m., which it reaches when the slip-rings of the first machine are short-circuited, and the second machine is there by entirely cut out of action.

The advantages of these characteristics are, of course, very great, and the peculiar merit of Mr. Hunt's invention consists in having enabled us to realise them practically in one machine instead of two, whereby all the disadvantages of poor power factor and efficiency and higher first cost, which are inherent in the use of two distinct machines, are avoided.

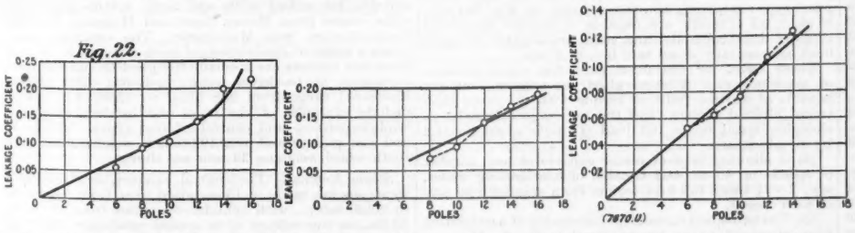
How this has been accomplished has very recently been described before the Institution,† so I will not discuss it again. It will be sufficient to say that the final result is a motor, of a type having only a single winding on each member, the stator being connected, on the one hand, to the line as a primary winding, and on the other to a suitable starter, the resistance of which is gradually cut out in order to bring the machine from standstill up to its cascade speed. This having been done, on further short-circuiting the resistances R placed across the slip-rings the motor will rise from its cascade speed to its maximum speed.

An alternative method of operation consists in having both sets of slip-rings on the one rotor and thus obtaining for a particular combination of numbers of poles a machine with six slip-rings, the same number as are required in the cascade set.

By short-circuiting three of these through a resistance, the machine is brought up to its lower speed, while by short-circuiting the remaining three it is brought up to its top speed. This method of starting is particularly advantageous for high-tension machines, since it avoids all high-tension switch gear and forms the only multi-speed induction motor in which it is possible to change speed without opening the circuit.

Internal cascade machines of this type, however, as built up to recent years were restricted to machines having their lowest efficient speeds corresponding to numbers of poles of 12, 18 and 24, &c., and to two definite ratios of speeds, namely, 3—2, and 3—1. While much work has been accomplished by this means, and great credit is due to Messrs. Sandycroft for the results obtained, it is believed that now that these limitations have been removed they will be able to cover a much

Fig. 22.



* F. Creedy, "Some Developments in Multi-Speed Cascade Induction Motors," *Journal I.E.E.*, 1921, vol. lix, page 511.

† F. Creedy, *Ibid.*

wider field. Machines can now be built the lowest speeds of which correspond to any number of poles exceeding six and having, in theory, any desired ratio of speeds. Certain practical limitations to the speed ratios of two-speed motors are introduced by the rule as regards the number of slip-rings required by such a machine. This rule is as follows :—

A motor to give a top speed corresponding to M poles and a bottom speed corresponding to (M + N) poles, will have a number of slip-rings equal to (M + N)/(G.C.M. of M and N).

For cases where either M or N is large and where there is no common factor between them, clearly the number of slip-rings may be higher than is desirable, but setting aside these cases a very large number of new ratios become available. For instance, confining ourselves to apparatus requiring less than six slip-rings the following combinations, among others, can be built :—

Ratio.	Speeds offered on 50 periods.
4—3	1,000/750 or 500/375, &c.
4—6	750/600 or 375/300, &c.
5—3	500/300 or 250/150, &c.
5—6	600/500 or 300/250, &c.

Some of these ratios are particularly important in certain classes of application, *e.g.*, in mine fan motors where the power developed decreases as the cube of the speed. In these cases the reduction from full speed to two-thirds is sometimes found to be too great and a smaller reduction, say from full speed to five-sixths or four-fifths full speed, may meet the conditions more fully.

Besides this, only a very small reduction is necessary for flywheel sets and in this case the new ratios prove also of very great advantage.

The slip regulator operating the rotor circuit of a two-speed cascade motor wastes very much less power, and consequently may be of very much smaller and lighter construction than when used as an ordinary single-speed induction motor.

So far we have dealt with the cascade set pure and simple, in which the speed-change can be effected without opening the stator circuit. By combining the cascade method with the pole-changing method previously described, machines may be built for three or more speeds. To do this the primary winding is adapted for several numbers of poles, which may be done in a variety of ways, although, due to its double function as primary of the first machine and secondary of the second machine, this is more difficult than where the winding only has to serve a single function as described in Part I. The same cascade speed may be obtained by means of several different combinations of numbers of poles, for instance, a cascade speed of (8 + 4) = 12 poles, may also be obtained from (10 + 2) = 12 poles, and it has been proved that a secondary winding which is adapted to work with (8 + 4) poles will work equally well with (10 + 2). Hence, if we have the primary winding of the machine arranged for 8 poles, and the secondary winding adapted to (8 + 4), the machine, if running on its cascade speed, will go at the speed corresponding to 12 poles and, if we short-circuit the slip-rings, will rise from the 12-pole speed (500 r.p.m.) to the 8-pole speed (750 r,p.m.).

If, while the machine is running at its cascade speed (500 r.p.m.), we change the number of poles in the stator winding from 8 to 10, which, of course, involves a switching operation, there will be no change in the speed of the motor. If, however, we now short-circuit the slip-rings, the machine will gradually rise from the 12-pole speed (500 r.p.m.) to the 10-pole speed (600 r.p.m.). Thus we have an apparatus preserving the unique characteristic of the cascade machine, viz., that of permitting a gradual regulation between speeds and yet having more than two speeds.

Large, low-speed motors having speeds in the ratios just mentioned, *e.g.*, motors running at 187/150/125 r.p.m. prove very advantageous in certain cases, for instance, in rolling mills. The principle just described may be extended to machines having four or more speeds, in all of which cases the cascade machine will rise from its cascade speed to any of the speeds for which the stator winding is adapted.

For instance, a four-speed machine adapted to speeds of 750/500/375/300 r.p.m. may be built. The limitations to the number of speeds which can be obtained by this process are due to the difficulty of designing the stator winding for a large number of different numbers of poles, and at the same time adapting it to act as a secondary.

Other Applications of the Cascade Machine.—In addition to its usefulness as a multi-speed machine, the cascade induction motor has a wide field of utility in other directions, to which we may briefly refer. It has been pointed out that it may be started with a powerful torque and brought up to its cascade speed by merely cutting out a resistance connected across the tappings on the stator winding. Such a machine will have a completely short-circuited rotor without external connections, and it realises the old desideratum of a squirrel-cage motor with slip-ring characteristics.

I need not do more than very briefly point out the great advantages of such a construction in dusty or inflammable atmospheres, and its much greater reliability.

It has often been pointed out that the power factor of the cascade motor is materially higher than that of the standard type of slip-ring induction motor running at the same speed. This is due to the following two causes.

(1) A cascade motor running at 500 r.p.m. is wound for 8 poles, and therefore the pole-pitch is 50 per cent. greater than in a standard 12-pole motor. The difference in leakage between an 8-pole and a 12-pole motor is very considerable, as may be seen in Fig. 22.

(2) The simple cascade rotor winding, approximating as it does more nearly to a squirrel-cage winding than to an ordinary slip-ring winding, gives rise to a much lower leakage, and these two causes, acting in conjunction, account for the higher power factor of the cascade machine.

Another application, which may possibly prove to be the most important of all, is as a synchronous machine for the purpose of improving the power factor. Such a machine has marked advantages over any other form of synchronous apparatus.

The chief drawback to synchronous sets for improved power factor has up to now been their high cost, which is largely due to the amount of auxiliary apparatus they require, in addition to the large number of exciting ampere-turns necessary to give an adequate overload capacity. Both these features are very much reduced in the synchronous cascade set.

In order to understand this, consider a cascade set, consisting of two machines, the stator of the second of which is electrically coupled to the slip-rings of the first, while they are mounted on a common shaft. Let the second machine be arranged for two poles and the first machine for six poles, then, as is well known, the combination will run at 750 r.p.m. on a 50-period circuit, viz., at a speed corresponding to (6 + 2) poles.

The second machine will receive from the slip-rings a frequency one-quarter the line frequency, viz., 12·5 periods per second. As is well known, the rotor of the second machine of the cascade set may be of any desired type, *e.g.*, either of the squirrel-cage type, the slip-ring type, or even the revolving field of a synchronous motor.

On the rotor of such a secondary synchronous motor a number of ampere-turns must be provided, equal to that on the stator, plus the amount necessary to produce the magnetic flux in this secondary machine.

Now, in the internal cascade motor, the ratio of the total flux (flux per pole × number of poles) in the parts corresponding to the primary and secondary motors in the cascade set which we are now discussing, is fixed by the construction of the rotor winding and is nearly equal in both cases. Consequently, a cascade set corresponding to the internal cascade machine would have the same total flux in both its constituent machines. If the magnetic densities are the same, as they must be, since both fluxes are carried by the same iron, it follows from fundamental electromagnetic laws, that the turns per pole necessary to produce these fluxes in the primary and secondary machines are also nearly equal, and, since there are only two poles in the secondary motor to be excited instead of eight poles in a synchronous motor of normal construction running at the same speed (750 r.p.m.), only one-quarter of the exciting watts are needed.

This shows itself in practice in the very much reduced size of exciter required by a cascade synchronous motor as compared with the older type. This characteristic renders the synchronous cascade motor feasible from the point of view of cost in much smaller sizes than any other type of synchronous machine.

Summary of Characteristics of Variable-Speed, Alternating-Current Motors Without Commutators.

(1) A large variety of speed combinations is available, giving any number of speeds up to five (or six with a panel-type controller), *e.g.*, those shown in Fig. 13 (page 89 *ante*), all of which are capable of control by simple types of drum controller and some are capable of being built economically down to 2 h.p. or 3 h.p.

These have, for the most part, the characteristics of machines with short-circuited secondaries, but are capable of starting full-load torque with not more than twice full-load current, and the rate of acceleration in changing speed under full load is under exact control by simple means.

(2) A slip-ring type of motor capable of any number of speeds up to six and capable of accelerating under, say, 2—2½ times full-load torque from standstill to any of such speeds.

(3) The two-speed cascade motor capable of accelerating from standstill to its lowest speed under 2—2½ times full-load torque by resistance control, and then rising from its lower to its higher speed by short-circuiting a resistance connected across the slip rings. These two speeds may have practically any desired ratio. Speed-change is here effected without opening the stator circuit.

(4) A multi-speed cascade machine capable of starting and accelerating to its lowest speed in the manner just described, and then of rising from that speed to any one of its other speeds on short-circuiting the slip-rings.

I believe it will be admitted, as a result of what has been said above, that it is possible to meet practically every condition of variable-speed working required in industrial practice by an appropriate method of control applied to the ordinary induction motor, this control involving no continuous waste of power or other undesirable features, and consisting merely of simple and well-known types of switch gear, and, in some cases, small transformers.

For the few remaining cases in which an absolutely gradual speed-variation is required without loss of power, we have the polyphase commutator motor, with movable brushes as was described, for instance, in the paper by Mr. Teago.*

Hence I feel that I should have no difficulty whatever in recommending a suitable variable-speed alternating-current motor to meet the conditions of any industrial problem whatever, and that no cases remain in which it is either necessary or desirable to convert to direct current for the sake of obtaining variable-speed operation.

* *Journal I.E.E.*, 1922, vol. lx, page 328.

CATALOGUES.

Silent Gears.—A little pamphlet from the Westinghouse Electric and Manufacturing Company, East Pittsburg, U.S.A., gives much useful data relating to their pinions which are made of a special fabric impregnated and compressed so as to produce a suitable material on which durable teeth may be cut. Applications to electric motors from ¼ h.p. to over 100 h.p. are illustrated.

Electrical Fittings.—A pocket catalogue of electrical fittings, suitable for use by those in charge of contract work, and uniform with their marine pocket catalogue, has been issued by the General Electric Company, Limited, Kingsway, London, W.C.2. The catalogue includes particulars of a wide range of accessories for power, lighting, ventilating, cooking, line construction and other branches of electrical work.

Electric Accumulators.—The storage of electrical energy is now attracting increased attention in connection with the operation of motor vehicles, and strong claims are made for the nickel-iron-alkaline system with respect to steady discharge, non-deterioration during rest, and general robustness and reliability of construction. Persons interested in this matter will find a 20-page pamphlet issued by Messrs. Batteries, Limited, Redditch, worthy of attention.

Coal and Ash-Handling Plant.—A comprehensive catalogue of mechanical equipment for conveying coal and removing ash to and from boiler houses has come to hand from Messrs. E. Bennis and Co., Limited, of Little Hulton, Bolton, and 28, Victoria-street, London, S.W.1. The plant includes machines for tipping trucks, elevators and conveyors of several kinds, coal crushers, barge unloaders, pneumatic and other ash conveyors and practically all appliances for handling coal or other loose materials.

Petrol and Paraffin Engines.—A supplementary priced catalogue of a 4½-in. series of four-cycle petrol and paraffin engines has been received from The Parsons Motor Company, Limited, Southampton. The 4½-in. cylinders each develop 7 h.p., and engines are made up with one, two, three, four and six cylinders, so that horse-powers of 7, 14, 21, 28, 42, are obtainable. The engines are made in both marine and stationary types. A clear description of the main components is given with particulars of guarantees and prices for 1923 are also quoted.

Aeroplane.—An aeroplane to carry pilot, two passengers and 75 lb. of luggage, made by the Bristol Aeroplane Company, Limited, Filton, Bristol, is described in a little pamphlet received from that firm. The engine is a 100-h.p. air-cooled radial; the upper and lower wings are identical and interchangeable; the weights are 1,210 lb. for the machine empty, 215 lb. for fuel and oil, and 2,000 lb. for the machine fully loaded. The climbing power is 1,000 ft. in 2 minutes and the speed about 90 miles per hour, while the running cost is given at less than 1*d.* per mile per passenger. The aeroplane has thus entered the sphere of catalogued commodities, in which it will doubtless establish itself in due course.

Steam Engines.—An interesting catalogue of steam engines and parts such as crankshafts, flywheels, rope pulleys, cut and cast toothed gearing, and heavy castings suitable for rolling mills and large textile and paper mills, comes from Messrs. Scott and Hodgson, Limited, Guide Bridge, near Manchester. The catalogue comprises a series of illustrations of work done, as in all such cases the engines are specially designed to suit the local conditions as to drive, water, fuel, &c. The engines illustrated range from 250 i.h.p. to 12,000 i.h.p., and include examples of the cross and tandem-compound, triple-expansion and central-exhaust types. Flywheels and rope pulleys well over 100 tons in weight, and a spur tooth wheel weighing 39 tons are shown.

Steam Engines.—The central exhaust, or "uniflow" steam engine, made in 15 standard sizes, from 164 b.h.p. to 2,460 b.h.p., with cylinder diameters from 17 in. to 60 in., is the subject of a special catalogue issued by Messrs. Galloways, Limited, Manchester, and 11, Queen Victoria-street, London, E.C. These engines are very simple and compact, economical in steam and lubricant consumption, give a good turning effort and are in every way suitable for driving factory shafting, pumps, &c. They are made for wide adjustments of speed and can be arranged for very slow running, as is required for certain classes of work, by the application of special governors and valve gear. The catalogue, which also describes tandem-compound engines for use where large quantities of heating steam are required in addition to power, is of exceptional interest, especially to those considering alterations to power plants with a view to obtaining reduced fuel consumption.

Motor Taxation in Great Britain.—The Ministry of Transport has issued figures of the number of motor, &c., licenses issued from December 1, 1921, to November 30, 1922, and of the tax collected in that period in Great Britain, as returned by the local authorities, together with the approximate number of licenses current on November 30. The total gross receipts shown in the returns amount to £11,523,831. This figure is subject to some adjustment as regards refunds, &c. The total number of motor vehicles, excluding tramcars, in respect of which licenses were current on November 30, may be taken as 919,000, including 294,000 cars taxed on horse-power, 352,000 cycles, 159,000 commercial goods vehicles, and 72,000 motor hackneys. The average receipt in respect of a whole-year license was £17 12*s.* for cars taxed on horse-power, 2*l.* 13*s.* 6*d.* for cycles, 21*l.* 13*s.* for commercial goods vehicles, and 23*l.* 10*s.* for motor hackneys.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

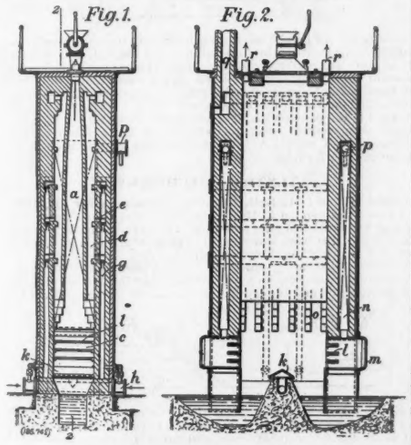
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

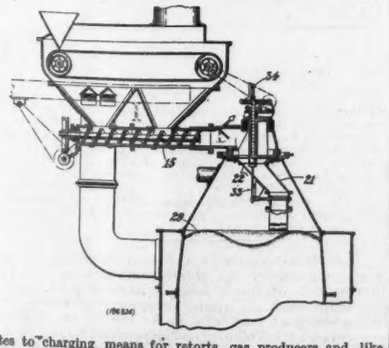
GAS ENGINES, PRproducers, HOLDERS, &c.

185,742. Woodall, Duckham and Jones (1920), Limited, London, Sir A. McD. Duckham, K.C.B., London, and A. T. Kent, London. Gasification of fuel. (2 *Figs.*) July 20, 1921.—The invention relates to an improved method of operating the generator in apparatus for the complete gasification of fuel. According to the invention, the air blast for the blow is introduced vertically upwards along the middle line of a mass of fuel having a horizontal cross-section considerably longer than it is wide, and the steam blast for the run is introduced horizontally at the end or ends of the cross-section, being preferably reversed at each run or during each run. The retort *a* is heated by combustion of producer gas made in the generator *c*, this gas being burnt in the flues *d* by secondary air admitted from flues *g* through ports *e*. The secondary air is supplied under pressure from the primary air main *h*. The primary air main extends through the middle of the generator, transversely thereto and below the grate. The delivery of the primary air is, however, above the grate, beneath a distributing hood *k* which extends across the generator. The



ends of the generator are constructed as grates *l*. These grates are covered by doors *m* and the chamber formed between each door and the corresponding grate is in communication with a flue *n* in the retort setting, which flue is packed with chequer brickwork. In operating the generator, the products of the "blow" pass up the passages *o* into the flues *d*, where they are burnt. When the "blow" has been continued for a short time, air is cut off from the main *h* and steam is blown in at the top of a flue *n*, which it descends to enter the generator *c* through a grate *l*. The bulk of the water-gas thus generated passes away through the grate at the opposite end of the generator into the other flue *n*, which it ascends, imparting heat to the chequer work and finally passing to the main pipe *p*. At the end of this "run" follows another "blow," after which the steam is introduced down the flue *n* which has just been heated by the water-gas, and the water-gas now produced ascends the flue at the opposite end of the setting. The waste gases from the flues *d* escape by a chimney *q*, and the distillation products are withdrawn from the retort through pipes *r*. (*Sealed.*)

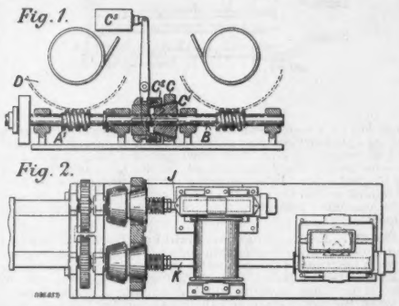
186,834. The Firm, Merz and McLellan, Newcastle-upon-Tyne and Westminster, London, E. G. Weeks' Monkseaton, and A. W. Statters, Newcastle-upon-Tyne. Charging Retorts. (2 *Figs.*) October 7, 1921.—The invention



relates to charging means for retorts, gas producers and like apparatus to which the material to be treated is fed substantially continuously during the operation of the retort. According to the invention, charging means comprises a distributing device 21 mounted within the retort with its receiving end 22 co-axial with the retort axis and its delivery end eccentric thereto, a conveyor device 15 to deliver the material to be treated continuously to the receiving end 22 of the distributor 21, and means to rotate the distributing device continuously (or substantially so) during the operation of the retort. Preferably, the delivery end of the distributor 21 is so constructed that it can trail on the surface of the bed of material 29 in the retort, and is free to move vertically in accordance with the variations in the depth of the bed. For example, the distributor may be provided at its delivery end with a trailing extension pivoted on the body of the distributor for movement about a horizontal axis, and preferably in such a manner as to form a substantially dustproof connection between the distributor and the trailer. According to a feature of the invention, there is provided a member (such as a rod 33) guided for vertical movement and having one end operatively connected to the delivery end of the distributor 21 and the other end extending to a point outside the retort, where it forms an element of a visual indicator 34, by co-operating with a fixed scale or equivalent reference. By this means an indication of the upper surface level of the bed of the material in the retort is given, and also an indication of variations throughout that surface. (*Sealed.*)

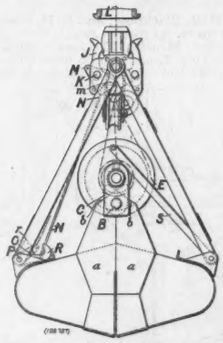
LIFTING AND HAULING APPLIANCES.

186,657. Ransomes and Rapier, Limited, Ipswich, and R. S. Lewis, Ipswich. Hoisting and Luffing Mechanism. (3 *Figs.*) June 2, 1921.—The invention comprises arrangements of hoisting and luffing gear for cranes of the type in which both hoisting and luffing gears are connected to a single source of power so as to be driven separately or simultaneously, the gearing not in use being automatically braked. In the construction illustrated, a driven shaft, normally braked by a stationary member, is coupled to a co-axial driving shaft, the axial movement of the clutch member progressively releasing the brake and engaging the clutch elements. In the form illustrated in Fig. 1, a worm shaft A^1, connected to the source of power, drives the hoisting drum D directly, and is fitted with the sliding element C^2 of a friction clutch for



coupling it to the co-axial worm shaft B for driving the luffing drum. The engaging movement of the clutch moves the shaft B axially against the pressure of the load to release the clutch element C^1 from the fixed brake cone C, the brake being re-applied automatically as soon as the clutch is relieved. Preferably the drums are wound so that the raising of the load is accompanied by a lowering of the jib to give approximately horizontal traverse of the load during luffing. A solenoid C^3 may be used to operate the clutch. In a modification, the clutch and brake surfaces are flat discs instead of being conical. In a further modification, Fig. 2, two geared parallel shafts J, K are employed for driving the hoisting and luffing drums respectively, each shaft being fitted with clutch-and-brake mechanism similar to that shown in Fig. 1. (*Sealed.*)

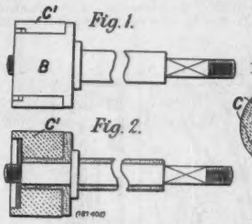
186,757. Stothert and Pitt, Limited, Bath, and L. Bacon, Bath. Grabs. (6 *Figs.*) July 30, 1921.—In a single or double chain grab in which the inner edges of the buckets are hinged together and are raised towards the grab-head for closing by means of a purchase drum E, this drum is carried by links C above the bucket hinge B, so as not to come into contact with the material, and the hinge plates *a* of the buckets are shaped at *b* so as to form lateral supports for the barrel shaft in all positions of the buckets. The grab-head gear shown comprises slotted hooks or links J which can be supported on a suspension ring L, or on a hold rope for discharging the grab as described in specification No. 178,517, the catch mechanism described in that specification for transferring the weight of the open grab from the suspension ring or hold rope to the hoisting rope being replaced by the



mechanism described below. A plate M is pivoted on the grab head at K and on one of the hooks J at *m*, and is connected by a rod N to an arm O pivoted on the fulcrum pin P of one of the buckets. The arm O carries a stop for engaging recesses *r* in slotted hook plates R which can turn and slide on the pin P. When the grab is supported by the hooks or links J, these hooks or links are turned outwards on their pivots K, and the plate M is turned about the pivot K so as to raise the rod N and arm O. The grab is now opened by lowering the barrel E; the hooks R resting on the bucket turn downwards until supported by the engagement of the stop in the recess *r*, and links S, pivoted on the fulcrum pin of the other bucket and resting on the barrel, come into engagement with the hook plates R. When the hoisting chain is hauled in, the buckets cannot close further than the position last indicated, since the links S engage the hooks R and prevent outward movement of the fulcrum pins P. The load is therefore transferred from the suspender ring to the hoisting chain; the rod N supports the plate M, and the hooks J fall outwards, turning about the pivots *m*, and are released from the suspender ring. When the open grab is lowered on to the ground and the hoisting chain becomes slack, the hooks R fall clear of the links S and the weight of the parts O, N, M, J brings them into the position shown in readiness for engaging the suspender ring. As the chain is hauled in, the bucket raises the hook R to the original position. (*Sealed.*)

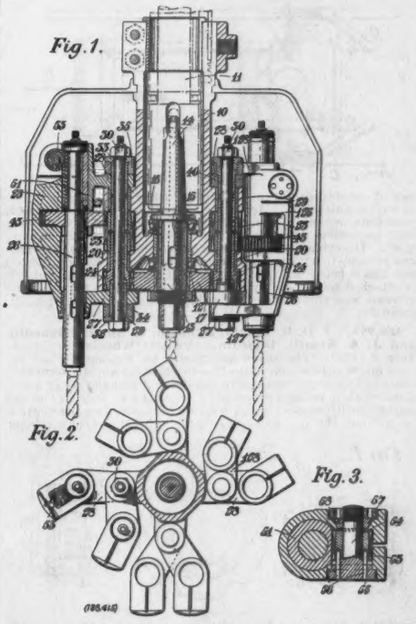
MACHINE AND OTHER TOOLS, SHAFTING, &c.

187,402. H. A. Findlay, Cardonald, near Glasgow. A Tool for Grinding Cylinders. (4 *Figs.*) August 31, 1921.—The improved grinding tool is of the type having radially-projecting spring controlled segmental grinding elements supported in a cylindrical body. In accordance with the invention, the improved grinding tool consists of a metal cylindrical body B



in which a pair or pairs of oppositely-disposed segmental recesses C are formed in which are mounted carborundum or other abrasive blocks C^1 with the outer faces curved to the curvature of the cylindrical body, the recesses or pairs of them being connected by passages F extending through the body, springs G being disposed in said connecting passages. (*Sealed.*)

186,415. G. Hey, St. Margarets-on-Thames, and J. A. Wilding, London. Multiple Spindle Drill Heads. (5 *Figs.*) June 24, 1921.—In a multiple spindle drill head of the type in which a support attached to the machine spindle carries a central gear which drives two or more drill sockets through gearing on intermediate parallel shafts carried by the support, the central gear meshes with the lower portion of each intermediate gear wheel, the upper portion of which meshes with a pinion on the drill socket, so as to reduce the height of the drill head to a minimum. In the form shown, the support 10, which is attached to the rack sleeve 11 of the machine spindle, has a head 12, in which is mounted in bearings 15, 16 the driving spindle 13 which is secured by a tang 14 into the machine spindle and is provided with a central drill and a central gear wheel 17. The support has a series of pairs of lateral eyes, each of which is bushed to form a bearing for an intermediate wheel 23, 24, the lower part 24 of which meshes with the wheel 17. The parts 23, 24 may be of the same or different diameter. Each drill socket 26, to which is keyed a pinion 43 meshing with the wheel 23, is mounted in a bracket 25 having upper and lower bushed lugs

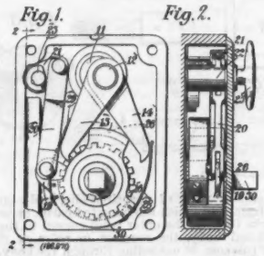


28, 27 mounted in the eyes so that the bracket may be angularly adjustable about the axis of the intermediate wheel. The bracket is secured in position by a bolt 29 and nut 30, in order to facilitate mounting and dismounting, the bolt forming the axle of the intermediate wheel and passing through the eyes and lugs. The bushes 33, 32 in the lugs may be separated from the outer surfaces thereof by distance pieces 35, 34 which, however, may be replaced by lugs 128, 127 on a second bracket 125, when it is desired to mount two drill brackets on the same bolt. The lengths of the lugs on the brackets 25, 125 may be different so as to secure a greater degree of adjustability of the drill head. In this case the pinion 43 on the second bracket, which meshes with the same intermediate wheel, is on a lower level than that on the first bracket in order that the brackets may be swung close together without the pinions fouling one another. More than two drill brackets may be mounted on the same bolt. The bushes 33, 32 and distance pieces 35, 34 may be replaced by three diameter split bushes 40 having separate shoulders for engaging the lugs on the separate brackets. Each drill socket may be independently adjusted axially through its pinion 43

in order to drill at various levels, by a rack sleeve 51 and pinion 53, the pinion being mounted on and pinned at 56, Fig. 3, to a bolt 54 in the split upper end of the bracket and rotated by a key inserted in holes in the bolt. The socket is clamped in adjusted position by a nut 57 which engages a tapered washer 58. In a modification, the eyes are provided on internally-flanged sleeves, which are mounted on the support 10 as to be angularly adjustable thereon, and so as to be capable of being removed therefrom together with the intermediate wheels and brackets, and replaced by others of different size. (*Sealed.*)

MINING, METALLURGY, AND METAL WORKING.

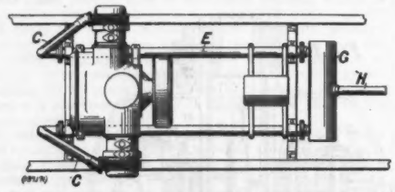
186,971. M. S. Moore, London, H. Jubb, London, and Cowlishaw, Walker and Co. (1920), Limited, London. Coal Cutters. (4 *Figs.*) June 10, 1921.—The invention relates to coal-cutters of the cutter-bar or cutter-chain types wherein the swinging movement of the cutting member is effected through a pawl-and-ratchet device operated by the driving mechanism of the cutting member. The invention comprises a shaft 11 that is driven from the cutter-driving mechanism and carried by an eccentric pin 12, whereon two oppositely-directed



pawls 13, 14 are pivoted to co-operate with a ratchet wheel 16. A pawl controlling member 19, 26 is loosely mounted on the ratchet-wheel shaft 30, so as to lie between and engage the two pawls 13, 14. A handle 25 is connected through intermediate parts 20, 21, 22, 23 with the member 19, 26. This handle 25, when moved, swings the pawls 13, 14 alternatively into and out from engagement with the ratchet wheel. Controlling springs 28, 29, which press the pawls into their engaging position, are mounted on the pawl-controlling member 19, 26. (*Sealed.*)

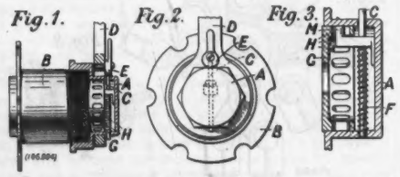
MOTOR ROAD VEHICLES.

187,171. The Vulcan Motor and Engineering Company (1906), Limited, Crossens, Southport, and E. G. Grinham, Crossens, Southport. Motor-Road Vehicles. (2 *Figs.*) January 19, 1922.—On motor-road vehicles where internal-combustion engines, with or without change-speed gear boxes, are used, it is common practice to mount the complete power plant on a sub-frame which is often detachably carried in the motor road-vehicle. The invention relates to power-plant mountings of this type. The sub-frame consists, as is frequently the case, of a



pair of suitably-spaced tubes E, to which the engine and gear-box (if any) are attached. According to the invention, these tubes E constitute sections of the exhaust-pipe system, which is particularly convenient when the cylinders are arranged in two or more rows. The exhaust branch C from each cylinder extends forwards and joins up to a flange on the front end of one of the longitudinal sub-frame tubes E. The rear end of each sub-frame tube E is attached to the end of a silencer G common to both exhaust systems, and this silencer has a single central discharge pipe H. (*Sealed.*)

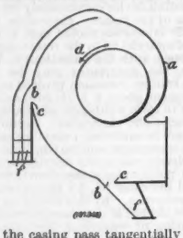
186,994. J. D. R. Smaill, Dunedin, C. Smaill, Dunedin, and J. A. Smaill, Dunedin. Vehicle Wheels. (3 *Figs.*) July 7, 1921.—The invention relates to locking devices for securing vehicle wheels of the kind in which the wheel is secured to a sleeve by a cap A screwed to the sleeve B with the aid of a ring spanner D, a spring-pressed pin C mounted to slide in the cap engaging with means formed in a ring G provided on the sleeve B o prevent the cap from unscrewing, the ring spanner being



provided with a cam E to depress the spring-pressed pin while the cap is being screwed to the sleeve. According to the invention, the ring G is provided with elongated holes H with which a stop-pin M provided on the spring-pressed pin C engages, and until this stop-pin is in engagement with one of the holes H the spring-pressed pin C protrudes at its end remote from the cam beyond the cap A to prevent the removal of the ring spanner before the parts are properly locked. (*Sealed.*)

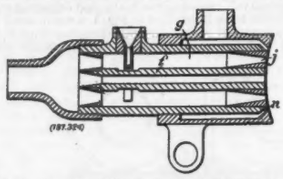
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

187,348. Babcock and Wilcox, Limited, London, F. G. Walton, Finchley, and S. Thursby, Sutton. Centrifugal Induced Draught Fans. (2 *Figs.*) July 28, 1921.—The invention relates to means for removing dust, grit and the like from air or gases, and is principally intended for use in connection with boiler furnaces. The invention consists in the feature that a single fan is employed in conjunction with a fan casing having dust-collecting pockets leading from slots in the peripheral wall, and arranged for axial inlet and peripheral discharge of the air. As shown, and in accordance with the invention, in the outer periphery of the fan casing *a* is provided a number of openings *b* presenting fine edges *c* to the gases flowing in the direction of the arrow *d*, each opening communicating by way of a passage in the casing *a* with a pocket *f*. The dust, grits or chips thrown



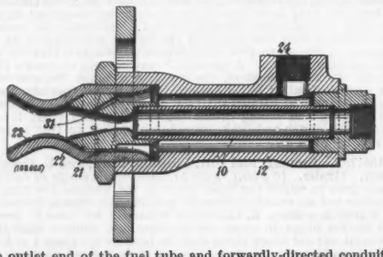
to the outside of the casing pass tangentially through the openings *b* and passages to the pockets *f*, from which the dust and grits may be removed at convenient intervals either direct or by means of chutes and valves. (*Sealed.*)

187,324. W. B. Wattson, Stoke Newington. Liquid Fuel Burner. (2 *Figs.*) July 18, 1921.—The invention relates to liquid fuel burners of the kind in which oil introduced into a chamber in drops or in a spray is ejected therefrom by a liquid under pressure, and wherein the pressure fluid is also caused to issue within and/or around the jet of fuel to ensure complete atomisation of the latter. According to the invention, a cylindrical burner comprises an annular chamber *g* into which oil is introduced in



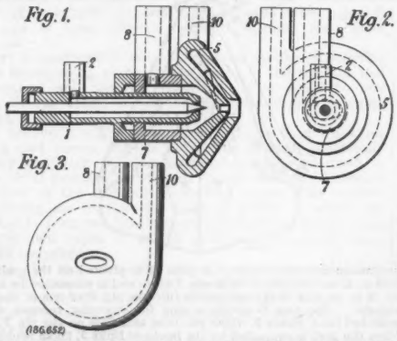
drops or in a spray, and from which it is ejected through a ring of outlet orifices *j* by steam or air or a mixture of steam and air under pressure, fluid under pressure being also caused to issue from a tube *f* concentrically within the ring of outlets *j* for the fuel. In addition, outlets *n* for fluid under pressure may be formed around the outlets *j* for oil so that streams of pressure fluid converge upon the fuel to complete its atomisation. (*Sealed.*)

188,025. J. Bliss, London. Fluid Fuel Burners. (3 *Figs.*) July 1, 1921.—According to the invention, a burner or sprayer comprises a fuel tube 10 through which the fuel is to be passed in an axial direction, a jacket 12 surrounding the fuel tube with an inlet 24 for steam, forwardly directed conduits 31 communicating between the jacket space and the interior of the fuel tube near its outlet end to lead steam from the jacket space into the fuel tube to mix with the fuel before it leaves the tube, a nozzle 23 enclosing



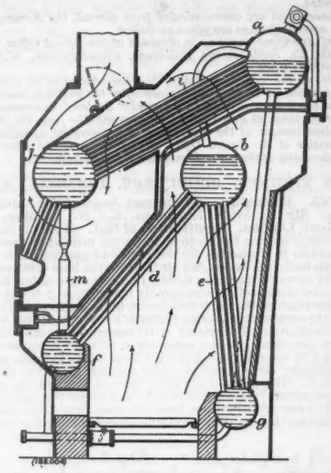
the outlet end of the fuel tube and forwardly-directed conduits 21, 22 exterior to the bore of the fuel tube and so disposed as to lead streams of steam to commingle with the fuel mixture as it issues from the fuel tube outlet into the nozzle. Both sets of forwardly-directed conduits 31, 22 also converge towards the axis of the fuel tube; and it is preferred that the conduits 22 are inclined across the axis of the fuel tube. (*Accepted November* 15, 1922.)

186,652. L. Hall, Blackpool, and S. H. Flood, Chatham. Liquid Fuel Burners. (4 *Figs.*) June 1, 1921.—The invention relates to liquid fuel burners. The burner comprises an inner tube 1, an outer tube 7, and one or more nozzles opening in advance of the inner and outer tubes, through which the liquid



fuel and steam and air are to pass, and, according to the invention, the improved burner comprises concentrically arranged inner and outer tubes 1, 7, a nozzle-piece 5 having a nozzle opening in advance of said tubes, and separate feed tubes 2, 8, 10, to both of said tubes and to said nozzle-piece, all of these feed tubes being arranged tangentially. (*Sealed.*)

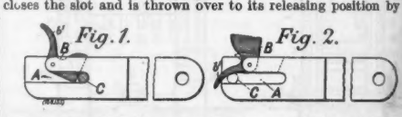
188,004. F. E. Rainey, London. Water Tube Boilers. (1 *Fig.*) April 29, 1921.—The improved construction of boiler constituting the invention comprises a pair of transversely-arranged steam and water drums *a*, *b*, at different levels in the boiler setting with their steam spaces directly connected, a pair of transverse lower water drums *f*, *g*, one, *g*, behind the furnace and at substantially the same level, and one, *f*, above the front of the furnace, and an upper transverse water drum *j* connected by water tubes *i* with the upper steam drum *a*. The rear lower water drum *g* is connected directly with the upper steam drum *a* by downcomer tubes. Further, the baffling arrangements controlling the path of the furnace gases are such that these gases



traverse in two parallel streams the two sets of steam generating tubes *d*, *e* connecting the lower steam and water drum *b* with the front and rear water drums *f*, *g*, respectively, and after passing around the two sides of the lower steam drum *b* are led in two or more passes transversely across the tubes *i* connecting the upper stream drum *a* with the upper water drum *j*. The upper water drum *j* is connected with the front lower water drum *f* by water tubes *m*, preferably comparatively few in number and of large diameter, and provided with constrictions at an intermediate point of their lengths. (*Sealed.*)

TEXTILE MACHINERY.

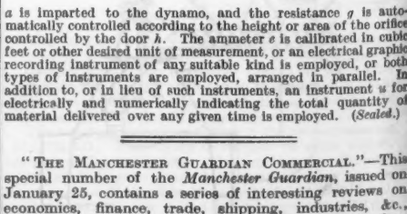
188,135. W. M. Bell, Dundee. Bearings for Spindles. (3 *Figs.*) Setpember 9, 1921.—The invention relates to bearings which will enable spindles and other articles to be quickly removed in a lateral direction and prevented from working or coming out of the bearings accidentally during use. According to the invention, the bearing comprises a slot A that is open at one end and has pivoted therein a weighted tumbler lever which normally closes the slot and is thrown over to its releasing position by a



tail-piece *b*1, which then spans the open end of the slot, and is so shaped that when the roll spindle C is removed from the slot it bears against such tail-piece and turns the tumbler lever over to its operative position. In this position the bottom of the tumbler, presents an inclined surface to the spindle and is raised by such spindle as the latter is pushed along the slot. When the spindle clears the end of the tumbler lever, the latter falls and closes the slot. By the invention described all lifting is avoided, and the slot is closed positively. (*Accepted November* 15, 1922.

MISCELLANEOUS.

186,661. J. E. Lea, Manchester. Measuring Rate of Flow of Granular Materials. (2 *Figs.*) June 4, 1921.—The invention refers to apparatus for measuring granular materials delivered through an orifice by a conveyor of the endless or reciprocating type. According to the invention, a small permanent magnetic field dynamo *b* is employed, also one or more ammeters *e*, voltmeters or the like in circuit with the dynamo, and a resistance *g* also in circuit with the dynamo. Means are also provided whereby the motion of the conveyor



a is imparted to the dynamo, and the resistance *g* is automatically controlled according to the height or area of the orifice controlled by the door *h*. The ammeter *e* is calibrated in cubic feet or other desired unit of measurement, or an electrical graphic recording instrument of any suitable kind is employed, or both types of instruments are employed, arranged in parallel. In addition to, or in lieu of such instruments, an instrument *u* for electrically and numerically indicating the total quantity of material delivered over any given time is employed. (*Sealed.*)

"THE MANCHESTER GUARDIAN COMMERCIAL."—This special number of the *Manchester Guardian*, issued on January 25, contains a series of interesting reviews on economics, finance, trade, shipping, industries, &c., during the past year, relating to the United Kingdom as a whole, the Colonies and dependencies, and foreign countries. Various trades and industries, such as cotton and other textiles, are also reviewed separately. The number is published from Guardian Building, Manchester.